US Army Corps
of Engineers
Construction Engineering
Research Laboratories

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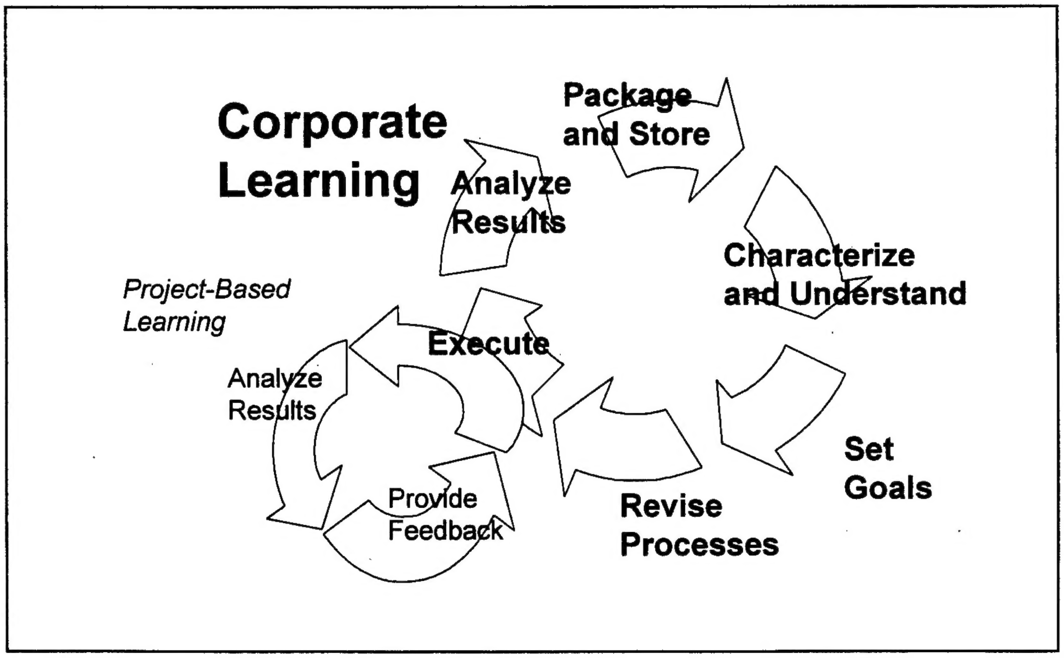
April 1997

# Design Review and Related Lessons-Learned Systems in the U.S. Army Corps of Engineers

edited by E. William East




These proceedings document a workshop held in January 1996 to identify requirements for design review and related lessons learned systems in the U.S. Army Corps of Engineers. Individual papers, written by workshop participants, document the experience of the Corps in the creation and use of processes and systems to support design review and related lessons-learned systems. A summary paper abstracts the reports of individual participants and documents conclusions reached at the workshop.

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# Foreword

These proceedings were printed for Headquarters, U.S. Army Corps of Engineers (HQUSACE) and the work performed under Project 4A162784AT41, "Military Facilities Engineering Technology"; Work Unit AP6, "Design Reviewer's Support Environment." The technical monitors were Justin Taylor, CEMP-ES, and Stan Green, CEMP-CE.

The workshop was hosted and the proceedings coordinated by the Engineering Processes Division (PL-E) of the Planning and Management Laboratory (PL), U.S. Army Construction Engineering Research Laboratories (USACERL). The USACERL principal investigator was E. William East. Dr. Michael P. Case is Chief, CECER-PL-E, and L. Michael Golish is Operations Chief, CECER-PL. The USACERL technical editor was Linda L. Wheatley, Technical Information Team.

COL James T. Scott is Commander and Dr. Michael J. O'Connor is Director of USACERL.

# Contents

# 1 Introduction

## Background

Many efforts have been made to develop design review and related lessons-learned systems throughout the U.S. Army Corps of Engineers. Developers and users of these systems expressed an interest in meeting to discuss the impact of recent technological advances in network computing, nonproprietary graphical presentation of contract plans and specifications, and object-oriented technologies.

## Objective

The overall objective of this meeting was to provide a forum for dialog between developers and users of design review and related lessons-learned systems across the Corps. This dialog should improve the quality of individual future products and reduce potentially duplicated effort.

The specific objectives of this meeting were to (1) determine the state-of-practice in design review and related lessons learned systems and (2) to identify directions for future product and system development.

## Approach

The approach taken in this workshop was to allow each participant to describe their role in the design review, lessons learned, and management functions. Following these presentations, breakout sessions were held to cover many issues raised during the presentations. A summary meeting following the breakout sessions was held to organize the conclusions reached on topics of interest. During this summary meeting, the group developed and prioritized a set of action items.

## Scope

This report documents information presented at the January 1996 workshop held at the U.S. Army Construction Engineering Research Laboratories (USACERL) to determine appropriate future directions for Biddability, Constructibility, Operability, environmental, code compliance and technical design reviews; and the application of lessons learned systems for design review within the U.S. Army Corps of Engineers. The opinions expressed and material provided in this report represent the best knowledge of the authors at the time

of that meeting and are not, necessarily, the official position of the U.S. Army Corps of Engineers.

## Mode of Technology Transfer

These papers have been published on the World Wide Web at the Design Review Tools Committee Homepage, http://www.cecer.army.mil/pl/ra/committee. The conclusions summarized and documented in the final paper of these proceedings (p 67) provide guidelines that will be used to develop future design review and related lessons learned products and systems.

# 2 Design and Construction Feedback Systems

by Terry Houghton[1]

Headquarters, U.S. Army Corps of Engineers (HQUSACE) Directorate of Military Programs publishes engineering and construction policy, guidance, and criteria documents. They also recognize that there must be a continuing evaluation of the functional responsiveness and technical performance of the Corps practices for design, construction, and post-construction for constructibility, engineering and technical sufficiency, life-cycle cost performance, lessons learned, technical feedback, and compliance with current design and construction criteria. HQUSACE has established various requirements and methods to obtain, evaluate, and incorporate recommended changes in design and construction policy, guidance, and criteria. The following are various requirements and methods currently employed by HQUSACE to obtain constructive feedback for updating their policies, criteria, and guidance documents.

## Department of Army Facility Standard Designs

Engineer Regulation (ER) 1110-3-113, "Department of the Army Facilities Standardization Program" addresses the following review, evaluation, and feedback requirements for the Department of the Army (DA) facility standardization program:

(a) Approved DA standard design packages are monitored and evaluated for responsiveness to user requirements and for technical adequacy. Revisions are made when they are determined appropriate by ongoing review and evaluation.

(b) A subcommittee for each standard facility type is responsible for evaluating the responsiveness of the DA standard design package to the user's functional and operational requirements. The subcommittee monitors facilities built using the DA standard design package, evaluates their responsiveness, and documents the findings.

(c) The supporting center of standardization (COS) for each facility type is responsible for evaluating the technical performance of the DA standard design package. The supporting COS monitors facilities built based on the approved DA standard design package (during construction and post-

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construction) for constructibility, engineering and technical sufficiency, life-cycle cost performance, lessons learned, technical feedback, and compliance with current design standards and construction criteria. The supporting COS documents the evaluation.

(d) The subcommittee and the supporting COS for each facility type coordinate their reviews and evaluations on an ongoing basis. As a minimum, the groups meet once a year and provides a summary of their actions to the Chairperson of the DA Facilities Standardization Committee. The supporting COS revises the DA standard design package when required.

## Corps of Engineers Guide Specifications

The use of Corps of Engineers guide specifications (CEGSs) in the preparation of project specifications is mandatory to the extent the guide specifications are applicable. The specifications allow contractors to provide optional materials and methods of construction that are of a type and quality acceptable for military construction, as a means of increasing competition and reducing project costs. Additional options may be considered if a study of conditions affecting the project shows that it is in consonance with good engineering practice in that locality, is economically justifiable, and is in the best interest of the Government. Where cumulative experience indicates that a change in standard options may be advisable, Division commanders are asked to forward their recommendations to HQUSACE (CEMP-EA) using ENG Form 3078, Recommended Changes to Engineering Documents. Also, as a normal use of CEGS, ER 1110-345-720, "Construction Specifications," recommends that technical or editorial changes that are necessary or desirable for general application or to adequately reflect local availability of materials and local construction practice be proposed via ENG Form 3078.

HQUSACE has two processes by which CEGS are updated to current industry standards and incorporates recommended changes generated by field personnel; the Notice Program and the Criteria Update Program. The notice program generally addresses minor changes that can be accomplished within a few weeks time, and the criteria update program generally addresses major changes requiring extensive changes and takes months to accomplish. The notice program updates the CEGS on a two month to one year schedule and the criteria update program updates the CEGS on a three to five year cycle. Both processes incorporate the ENG Form 3078 recommended changes, HQUSACE memorandums and HQUSACE-prepared engineering technical letters, feedback obtained through the DA standardization program, post completion inspections and design/construction evaluation program, and industry changes.

## Technical (Engineering) Criteria

Military program technical engineering criteria are published in the form of Army regulations, technical manuals, DA facility standard designs, engineer regulations, engineer pamphlets, engineer circulars, engineer technical letters, architectural and engineering instructions, master planning instructions, standard drawings, definitive drawings, and military handbooks. HQUSACE reviews and issues updated versions of the above documents on either a continuing or periodic basis (one to five year cycle). At the time these publications are updated, they incorporate all approved ENG Form 3078s and appropriate lessons learned, and a complete industry and standards update is conducted.

## Quality Management Reviews

ER 1110-1-12, "Quality Management," requires that all design deficiencies, improvements, and field changes necessitated by missing or incomplete design guidance/criteria data be documented and, along with recommendations, recorded and submitted to HQUSACE on ENG Form 3078. HQUSACE reviews and incorporates the recommendations into the criteria, policy, and guidance documents as appropriate.

HQUSACE conducts quality management reviews of each Division and District on a three-year cycle. During these reviews, many lessons learned surface, and HQUSACE representatives take note and initiate appropriate actions.

## Design and Construction Evaluation (DCE)

ER 415-1-13, "Design and Construction Evaluation (DCE)," addresses the following review, evaluation, and feedback requirements from ongoing military design and construction projects. This ER requires HQUSACE representatives to conduct annual evaluations of ongoing construction projects at various locations within each Division. All phases of construction execution are examined for compliance with contract provisions and HQUSACE guidance, design-oriented problems are investigated, and contract documents are reviewed for conformance with established guidance.

Upon completion of each field evaluation visit, the evaluation findings are reviewed and necessary technical findings are recorded in the Construction Evaluation Retrieval System (CERS) and maintained at CEMP-CE. The system's file is utilized for feedback and periodic distribution of common problems to the field. Comments on design and criteria items are distributed to the appropriate individuals in Engineering Division (CEMP-E) for necessary revision and addition to technical manuals and guide specifications. The inspection team is responsible for evaluating criteria deficiencies, recommending proposed solutions, and providing feedback information to appropriate HQUSACE proponents for consideration in initiating policy and criteria or specification improvements.

## Post Completion Inspection and Design Criteria Feedback Inspection

ER 415-3-11, "Post Completion Inspection and Design Criteria Feedback Inspection," addresses the following review, evaluation, and feedback requirements from completed military construction projects. This ER requires post completion inspections conducted to identify deficiencies or defects in design, construction, materials, equipment, operability, maintainability or functional adequacy of the completed facility. These inspections are conducted approximately six months after occupancy of a facility.

HQUSACE design guidance must be kept current, in part, through a program of periodic inspections of facilities that have been in use for two or more years or have been identified as having design criteria or functional problems. A two-year-old facility which has been user tested is inspected and pertinent comments, recommendations, description of facility deficiencies, evidence of poor serviceability of materials, equipment, or operations systems are recorded. The inspection team is responsible for evaluating criteria deficiencies, recommending proposed solutions and providing feedback information to appropriate HQUSACE proponents for consideration in initiating policy and criteria or specification improvements.

## Technical Centers of Expertise

Many military-unique engineering and construction areas are not readily available from the private sector engineering and construction consultants and must be available within the Corps family. To maintain many of these unique engineering and construction capabilities, HQUSACE has assigned centers of expertise responsibilities to designated Major Subordinate Command (MSC) and District commands. These centers are required to have a designated unique or exceptional technical capability in a specialized subject area, many of which involve emerging or rapidity changing technologies, not normally found but very beneficial to other military program USACE commands. All other MSC and District commands are instructed to coordinate with and use the expertise and services of the centers to satisfactorily accomplish their design mission.

ER 1110-3-109, "Corps-Wide Centers of Expertise Assigned to Major Subordinate Commands and Districts" covers the policy and responsibilities for military programs mandatory centers of expertise, technical centers of expertise, and centers of standardization. Center responsibilities include (1) assimilate and analyze lessons learned, (2) provide technical feedback, and (3) develop recommendations for updating and revising appropriate design-construction criteria, policy, and guidance documents. The centers recommend proposed solutions to appropriate HQUSACE proponents for consideration in initiating policy and criteria or specification improvements.

## Cost Engineering

ER 1110-3-1300, "Military Programs Cost Engineering," requires all cost engineering elements at each District to prepare and submit awarded construction cost information using the Historical Analysis Generator (HAG) cost data reporting system to HQUSACE (CEMP-EC). The HAG cost data are then reviewed, analyzed, assembled, consolidated and made available to all USACE elements and other services on an electronic bulletin board at U.S. Army Engineering and Support Center, Huntsville (CEHNC).

## Engineering Improvement Recommendation System Bulletin

Engineering Improvement Recommendation System (EIRS) Bulletins are part of the process for implementation of recommendations from information feedback sources, and are used in military construction programs to facilitate expedited dissemination of information regarding problems. The EIRS Bulletins are disseminated monthly to all MSC, district commands, laboratories, and Field Operating Agencies. The probable solutions included in EIRS Bulletins are not thoroughly explored or staffed. As such, the probable solutions will not represent a final HQUSACE position, and their use is not mandatory. Probable solutions are considered as informational in nature and for the purpose of permitting prompt consideration by the field. EIRS Bulletin recipients (all engineering offices) are encouraged to comment on the probable solution presented so that other viewpoints can be considered in the development of the final HQUSACE position.

## HQUSACE Technical Newsletters

HQUSACE publishes newsletters from individual technical disciplines addressing cost engineering, architectural, mechanical engineering, and electrical engineering changes in criteria, high interest topics, and associated developments and improvements. Included in these newsletters are lessons-learned topics related to each technical discipline.

## Staff Assistance Visits

The Corps of Engineers Center for Public Works (CECPW) conducts staff assistance visits to Army installations and provides feedback on engineering and construction problems they have encountered. HQUSACE initiates corrective actions as required.

## Corps-Wide Technical Conferences and National Team Meetings

HQUSACE sponsors various annual, biannual, and triennial Corps-wide technical conferences and national team meetings. During these conferences and meetings many lessons learned surface, and HQUSACE representatives take note and initiate appropriate actions.

## MCA Reprogramming Actions

HQUSACE reviews all reprogramming actions, develops lessons learned after performing an autopsy of failed projects, and issues these lessons learned to all Corps offices.

## PROSPECT and CONTRAST Training

All technical disciplines in the Headquarters Engineering Division have a number of PROSPECT and CONTRAST training courses addressing specific engineering and architectural topics associated with the Corps design and construction program. Each course's instructional material is updated annually with many technical engineering lessons-learned items incorporated into these updates.

# 3 Automated Review Management System (ARMS)

## The Automated Review Management System

by Stephen E. Stoner[2]

Biddability, Constructibility, and Operability (BCO) reviews for military projects in the Sacramento District (SPK) have used the Automated Review Management System (ARMS) since 1988. Engineering Division utilities design engineers in its Military Design Branch use ARMS to review A/E prepared designs and perform peer review for its in-house designs. Engineering Division has reduced its level of review detail. In-house peer reviews are not considered technical reviews. A/E design reviews address issues such as life and safety. Construction-Operations Division uses engineers and technicians in its Construction Quality Assurance Section, as well as Resident/Area Offices, to review all design packages prepared by Engineering Division.

ARMS is used by Sacramento District reviewers today for all major Civil Works, Military, and Hazardous Toxic and Radioactive Waste (HTRW) projects. Each reviewer uses PC ARMS for Windows, some standalone, while others, especially designers, use a LAN-installed version to respond to shared comments. Most using agencies' comments are uploaded to the Oracle 7 based ARMS Central; the remainder of user comments are placed in the ARMS Central program by Technical Managers.

Currently ARMS implementation barriers are primarily found in our using agency or customer base. The agencies with limited, infrequent use of ARMS will forward written comments to the Technical Managers to incorporate into ARMS. Information on the local and notional use of ARMS can be found in the ARMS usage section of these proceedings.

The Sacramento District military design process from final submission to bid opening was investigated by a Process Action Team in 1995. The Team's recommendations included continued usage of ARMS. The PAT did recommend changes to the design process, but not to the review process. The Team felt that changes in the design process would be the most effective means in reducing the cost of design related construction change orders.

Capture and reuse of lessons learned in the Engineering Division uses the Omaha District's designed and developed LAN system on our Sacramento

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District Banyan LAN. We have several lessons learned from each discipline now available to our in-house designers. Each design section is responsible for the selection and update of their discipline's listing of lessons learned; a coordinator in our Criteria Management Unit facilitates inputting the lessons learned in the database. The lessons-learned list is used by designers during the early stages of design to assure that they have screened their projects for possible repetitive errors. Refer to the Omaha District's description of their automated lessons-learned program for system capabilities.

An initiative to distribute electronic bid documents for review and other purposes was initiated by SPK in 1993, with a follow on coordinated effort with the South Pacific Division (SPD). To date, three Sacramento District in-house design projects have been sent electronically to our SPD offices to facilitate their QA review of our in-house MILCON design efforts. This district is now in the process of implementing an all electronic bid set deliverable process.

Engineering Division expects that, beginning in October 1996, its products will be advertised in an all electronic format. Review and comment of our electronic products will primarily use .tiff or Adobe Acrobat formats. The determination of which format to use will depend on the software available to each reviewer. Within the Sacramento District, 50 copies of Watermark Fax software are available to review .tiff files using its markup language. Watermark will also be used to receive using agency comments via fax. Multiple copies of Acrobat will also be available for both viewing and marking design review sets. Which format will become prevalent will be determined through usage.

Long term, Engineering Division's electronic products could be integrated into the rapidly developing Internet. As our contract designer/construction agents and customers connect to the Internet at +10 Mb speeds, all of us could be reviewing, bidding, and constructing Corps projects, programs, and services by way of the Internet. Our home page for testing these concepts is http://www .usace.mil/cespk.html. Comments and suggestions regarding our thoughts and efforts are welcome.

## ARMS Usage

by Jae J. Kim[3]

| District or Division Code | Central Site's Computer Name | Total Number of Projects |
|---|---|---|
| CEHND | hnd41 | 0 |
| CEMRK | mrk41 | 2 |
| CEMRK | spk41 | 18 |
| CEMRO | mrk41 | 1331 |
| CENAB | spk4l | 258 |
| CENAN | nan4l | 72 |
| CENAO | spk4l | 160 |
| CENAP | nap4l | 37 |
| CENAP | spk41 | 3 |
| CENCB | spk41 | 28 |
| CENCD | spk4l | 4 |
| ENCS | ncs4l | 9 |
| ENCS | spk4l | 4 |
| CENPA | spk4l | 9 |
| CENPP | spk4l | 1 |
| CENPS | nps4l | 32 |
| CENPS | spk4l | 21 |
| CEORL | spk4l | 17 |
| CEPOD | pod4l | 10 |
| CESAM | sam4l | 16 |
| CESAM | spk4l | 21 |
| CESAS | spk4l | 90 |
| CESAW | spk4l | 1 |
| CESPD | spk4l | 66 |
| CESPK | spk4l | 1486 |
| CESPL | spk4l | 51 |
| CFSWA | spk4l | 55 |
| CESWF | spk41 | 55 |
| CESWL | swl4l | 30 |
| CESWL | spk4l | 34 |
| CESWT | swt4l | 108 |
| CESWT | spk4l | 97 |
| CETAD | tad4l | 6 |
| CEWFS | spk4l | 2 |
| OTHER | spk41 | 42 |

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## An Insight Towards Measuring the Design Process

by Beth A. Brucker[4], Michael Golish[5], Astor Ts.Ang[6]

The intent of this study is to find ways of objectively measuring portions of the design process systematically. The Corps of Engineers, as indicated in Engineering Regulation 1110-345-700, divides the design document process into two parts: concept design phase (0 to 35%) and final design phase (36 to 100%), with design document reviews required at 35 and 95%. The first phase of this continuing study is the examination of the design document review process. Until recently, capturing and managing design review comments at these different phases was very hard to achieve. In the Corps of Engineers, reviewers developed handwritten design comments, often at scattered locations, with limited interaction with other reviewers or designers. Often, comments were not resolved, causing design issues to extend into the construction process. With the fielding of the U.S. Army Corps of Engineers Automated Review Management System (ARMS), it became significantly easier to manage review comments. Because of the availability of review comments in an electronic form, a content analysis of the design document review process was possible.

Comments from ten facilities typical to the commercial construction industry were selected from the Sacramento District of the U.S. Army Corps of Engineers. Both 35 and 95% design document review comments from each facility were coded into an extensive categorization scheme developed for this study. The categorization scheme classifies each comment by its: location in the documents, problem type, building system area, and related disciplines. The documents reviewed were either drawings, specifications, design analysis, estimates, or other required Army documentation. Subcategories of the problem type address issues concerning criteria, design, and documentation.

Once the comments were categorized, percentages of review comments for each category were determined. The most frequent problem type was the documentation subcategory for both 35 and 95% reviews. Documentation subcategories contain issues regarding document coordination, omissions, errors, format, presentation, and terminology. In addition, our study found that, of the building systems classified, mechanical, structural, sitework, and envelope are responsible for the majority of total incidents. This finding is similar to a previous study of professional liability cases on construction failures conducted by the University of Maryland's Architecture and Engineering Performance Information Center (AEPIC).

The next phase of this study is to collect the change order documentation of the ten facilities previously analyzed. It is hypothesized that a comparison of the

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[6] Commander, U.S. Army Construction Engineering Research Laboratory, ATTN: Ms. Astor Ts.Ang (CECER-PL-E), P.O. Box 9005, Champaign, IL 61826-9005.

analysis of the design reviews to an analysis of change orders of each project may show the benefits and/or deficiencies in the design review process. As a final strategy, it is hoped that a post-occupancy evaluation could give holistic insight towards measuring the design process.

### *Data Analysis Sheet Notation*

**Comment Location**
1. Drawings
2. Specifications
3. Analysis of Design
4. Estimate
5. Other documentation (e.g., DD1391, DD1354, RFP, VEP, etc.)

**Disciplines**
Standard List of ARMS disciplines

**Comment Type**
1. Mandatory Change/Requirement
2. Recommendation
3. Verification
4. Justify / Explain
5. Question
6. Reminder / Not needed at this phase / Next submission
7. Concurrence
8. Info
9. Duplicate
10. Reviewer Error

**Problem Type** (4 character field—use 0 if none)
1 Criteria
  11 Using wrong criteria / use other criteria
  12 Not in Compliance with requirement/criteria
  13 Not using current design criteria/source info (CEGS)

2 Design Issues
21 Scope
  211 Delineate scope of work (e.g., construct boundaries, extent, demolition)
  212 Not in contract scope / change in scope
  213 Missing feature / requirement
  214 Unnecessary feature / requirement
  215 Excessive use of feature / reqt. (reduce #)
  216 Inadequate use of feature / reqt. (increase #)
  217 Unenforceable requirement (not feasible)
  218 Assignment of Work (subcontr single/ prime)
22 Design analysis
  221 Questionable / incorrect assumptions

222 Increase / decrease performance of feature
223 Not customary / local practice
224 High maintenance / operations solution
225 Inadequate analysis
23 Design configuration
231 Change Design Solution (too complex, doesn't meet req.)
232 Size feature (size parking stall, transformer, AHU)
233 Routing or location of feature (control joints)
234 Clearances / soft and hard interferences
235 Match existing features (e.g., match keying schedule)
236 Relocation of existing feature
237 Use Standard detail
238 Use Standard Master Spec (CEGS)
24 Product / System selection
241 Feature not an option in CEGS
242 Inappropriate or illegal for local conditions / project
243 Inappropriate for Application
244 Not cost effective selection
245 Options overly restrictive
246 Select material/product/system with different performance/characteristics
25 Coordination
251 Systems/product interface/integration
252 Phasing of construction
253 Disposal of waste materials
254 Salvage/Reuse
255 Conflicting info

3 Documentation
31 Coordination
311 Conflicting information/? combine
312 Document Coordination/? combine
3121 Drawing/specs
3122 Drawing/drawing
3123 Specs/specs
3124 Draw / Support documents
3125 Specs / Support documents
3126 Estimate /Other documents
32 Omissions (---0)/ errors (---1)
321 Missing (or need additional) information/ errors
322 Missing detail / drawing / schedule/ errors
323 Missing specification text / errors
324 Missing symbol, reference, annotation, labels / errors
325 Missing calculations or support documentation
326 Dimension errors or missing dimensions
327 Not applicable to project, unnecessary info (spec para)
33 Format / Presentation of Information
331 Change format/orientation (note to schedule)
332 Compliance with specification, drawing, cost formats

333 Notes/notation/symbology/labeling/ annotations
334 Location of information (spec sect, sheet #)
335 Readability (line weight, lettering too small)
34 Terminology
341 Use of obsolete / inappropriate terms
342 Confusing / awkward phrasing / grammar
343 Spelling / typo / missing text
344 Use of inappropriate phrase (owner/ government)
345 Use of proprietary specifications, references, notes
35 Estimates
351 Inadequate detail (e.g., split into floors, wings)
352 Labor rates / productivity factors
353 Quantity errors / time estimate errors
354 Unit costs errors
355 Overhead / profit errors
356 Contingency errors
357 Midpoint of construction error
358 Price quote needed
359 Total Cost error

CEG Work Breakdown Structure
Not Applicable, unknown
Substructure
Structure
Roofing
Exterior Closure
Interior Walls
Interior Finishes
Specialties
Plumbing
HVAC
Special Mechanical Systems
Electrical
Special Electrical Systems
Equipment and Conveying
Site Preparation
Site Improvements
Site Utilities
General Rqmt, Contract Rqmt, Bidding Info
Multiple Systems

**Source Requirement**
Reviewer determination/Unknown
Code or Regulation (NFPA)
Design Criteria, Corps Policy (TM, ER, ETL, AE instruct)
District Policy (A/E Guide, AFM, AFR)
User Request / requirement
Industry practice

# 4 Developments at Corps Districts

## Huntsville Division's Survey of Corps Systems

by Linda Himmelright[7]

**CEHND** (U.S. Army Engineer Division, Huntsville):

Chem Demil - Request for Information (RFI), Engineering Change Proposal (ECP) (HND-draft; contractor-master) (Dale Campbell-205-895-1765)

AE Contracts - LL; not database; new procedures (Terry Burton-205-895-1381)

ED-ES-G - Guide Spec Bulletin Board (Jim Quinn-205-895-1821)

**CELMN** (U.S. Army Engineer District, New Orleans): Construction contract review (Robert Guillot-504-862-2938)

**CEMRO** (U.S. Army Engineer District, Omaha): HTRW LL (Claudia Wiethop-402-697-2561) Engineering Division LL (Nadir Khan-402-221-4915)

**CEORD** (U.S. Army Engineer Division, Ohio River): no work so far but will be using Mobile (John Hart-513-684-3803)

**CEORH** (U.S. Army Engineer District, Huntington): HTRW uses MRO HTRW (Brent Smith-304-529-5640) Construction reviewed Mobile (concern: lacking user-friendliness)

**CEORL** (U.S. Army Engineer District, Louisville): LL; Engineering; obtained from Omaha District (Jack Skinner, Value Engineering Ofcr-502-582-6058)

**CESAM** (U.S. Army Engineer District, Mobile): LL; joint Engineering/Construction (Glenn Howard-334-690-3447)

**CETAC** (Corps of Engineers Transatlantic Programs Center): Plans and Operations (Carroll McDonald-IM)

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## Omaha District's Use of ARMS

by Margie J. Crumley[8]

### *Background*

I am Margie Crumley, and I am the ARMS Coordinator for the Omaha District. ARMS is an acronym for Automated Review Management System and is the application that I work with.

My position at the Omaha District is as an Engineering Tech. The position was created in the late '80s to work with automation of reviews and to assist technical managers, then known as project managers, with getting ready for review conferences.

The Omaha District at that time was one of the districts CERL was working with on the development of ARMS. My understanding is that then the comments being entered needed to be done on a main frame, and Omaha District reviewers did not have the connectivity that would have been required. At that point, probably 1988, it was decided that Omaha District would bring on-board a programmer to write a program that could be used on an individual PC to do comments, and the program would be compatible with the ARMS program CERL was developing. The intent was to then upload the comments that were generated during the period to the main frame used for ARMS, after CERL developed this capability.

The Omaha District program was used on individual PCs initially and then moved to LANs. It was also furnished on disk to Architect-Engineers, and used by our in-house designers to make responses. The programming for Omaha District was done in Clipper, and the program that Omaha District ended up with was called COMNET. Interestingly, the same programmer developed "Omaha's Lessons Learned System" that you will hear about later. The Lessons-Learned program uses numerous modules from the COMNET program.

In 1990, when USACE decided to implement ARMS Corps-wide for reviews on Military projects and set up the TCX at Sacramento to do training at the Divisions and Districts, Missouri River Division (MRD) contracted with our programmer to work on an interface of our program with ARMS. Although work on this interface ended when MRD decided to move over to ARMS, I was part of the programming on the interface, and we did use it to send comments to ARMS from our program until ARMSWord, as the reviewer package for ARMS was known at that time, was made network compatible by the programmers at Sacramento. This did not happen until after the first ARMS User Conference in 1991.

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### Organization

*Personnel*

The Technical Managers (TMs) of the Design Branch all work with ARMS. The Environmental Branch TM's who work with Military projects also work with ARMS to some degree. On other Environmental Branch projects, the project is initialized on Engineering Division Network, where PCARMS is loaded. If our Omaha District reviewers are making comments on the design documents—the request to have the project initialized often comes from our own reviewers, who are used to doing comments using PCARMS. Some of the project managers from the PPM Division also use ARMS, but the request for ARMS use is generally made by someone outside the District that has used ARMS. We work with a few other TMs outside of Design and Environmental Branches of the Engineering Division—Geotech Branch, Operations Division, Planning Branch.

The reviewers in the Omaha District, with the exception of two Environmental Branch sections who have limited participation, are required to use ARMS. The projects are set up on the Engineering Division Network, and the reviewers who are not comfortable with doing comments there, because of an occasional loss of comments and having other reviewers in the file while they are there, have PCARMS loaded on the hard drive of their computer and do their comments there. When they are finished, their comments are uploaded to the network. Although Omaha District has numerous LANs and the PCARMS software resides on the Engineering Division network, our network individuals, and in particular Drew Anderson, have made a concerted effort to have anyone who has reason to access Engineering Division Network to be able to do it. The LAN for Environmental Branch, which is not in our building, is maintained by our IM personnel and also has full access to our network.

*Projects*

The August 1995 edition of the ARMS Newsletter shows Missouri River Division with 1,320 projects implemented on the MRK41 computer. This is considerably more projects than any other Division, outside of Sacramento, and not that many less than Sacramento. Approximately 75% of those projects are Omaha District's.

### Automated Review Management System Development

The rationale behind ARMS was to have all the players in the review arena be able to access a central location to upload comments and responses for a given project. The capability for tracking projects was also available. When USACE mandated that ARMS be used for Military projects in 1990, it was considered conceivably that Civil and HTRW projects would eventually be reviewed using ARMS also.

Omaha District's move to the MRK41 computer came in April of last year. The MRK41 computer is much faster in doing anything that is required on the Dell

computer that was used as the central computer and located at Omaha District. Although Oracle 7 is on the MRK41 computer, Missouri River Division has not moved over to the Oracle version of ARMS yet. The biggest reason why is the need for the ARMS coordinator to be able to work with the Oracle file when there are problems, as I am able to do now through the UNIX operating system. Sacramento is working through a program that they have written to give Omaha District that capability, and hopefully we will be moved over soon. The ability to work with the file is particularly crucial since the funding for the TCX has been cut back.

### *Omaha District Usage*

In my position, I work with all levels involved in the review process for ARMS. I have developed instructions for working with and without modems for reviewers and Architect-Engineer firms working with us, and they are furnished these instructions, along with my telephone number if they need help, when they are working with us.

Omaha District has made a concerted effort to have installations as well as other areas working with ARMS. Having worked with ARMS from the time that Omaha District moved over to ARMS, I feel that the concept of ARMS is a good one, and should help where reviews are concerned. I have in my files copies of review comments that are hand written, in some cases extremely difficult to decipher, and can remember the technical managers pulling the handwritten comments together by discipline for a review conference.

Construction Division at Omaha District has our field offices under them and has been particularly helpful on pushing for comments being submitted on ARMS. The flip side of that coin is assurance that annotations to their field offices' comments will show up on ARMS in a timely manner.

The way ARMS is set up to work, the TM goes to the central computer and initializes a project. At Omaha District I generally do it, after receiving a copy of the memo asking for comments. Next he sets up the phase being reviewed and then chooses the routing schedule. The routing needs to be to a login that is recognized by the ARMS central program. And just because you have a login for one central computer, you will not be able to work on another Division's central computer until the login is established there. This will not be the case when everyone is working with the Oracle version—you will be able to work anywhere you need to. At this time, Missouri River Division is still working with the old version; hopefully we will get moved over to Oracle 7 soon.

The TM routes to a login that is set up for either a review manager or a reviewer. If he routes to a review manager, the review manager will need to access the central computer and route the project to the reviewers.
At this point, the reviewer does not care about the routing. The reviewer has received a memo from the TM which probably forwarded the design documents and asked for comments back by a certain date. In the case of the Omaha District, we ask that there be a standard paragraph in the memo, advising that

the project has been initialized on ARMS, and asking that the comments be done using ARMS if possible.

The reviewer now sets up the project on his individual computer or, if he is working on a network, he chooses the applicable project (at Omaha District I set the projects up on the network) and does the review comments. After the comments are finished, if the reviewer has his own login and can get to the central computer, either through Procomm (the software that is furnished with the PCARMS software and dials in) or through the "telnet" capability, if available, he accesses the central computer and uploads his comments back to the TM.

At Omaha District we do not have that capability for our reviewers at this time, and the reviewers share a login—depending on what area they work in (i.e., Design Branch). Instead, after the comments on a project are finished, I will go ahead and export them from the network as an ASCII file and upload them to the central computer.

After the comments are uploaded from Engineering Division Network back to the TM, they are combined with comments that have been uploaded from our field offices or other installations that work with us, and the TM gets a printout of the comments for the review conference. At a recent review on a facility at Buckley ANG, we received better than 700 comments from the reviewers at Buckley. The people at Buckley had problems years ago with uploading their comments to us electronically and still opt to "overnight" a disk with their comments.

Of conceivably a more critical nature, our field offices are able to get comments to us on Bid Documents in a matter of minutes, and this has us looking at fewer amendments or modifications at the bid stage.

The final "leg" on the review process at Omaha District is to send the annotated comment file to the designer, either our in-house people or the Architect/Engineer. The designer then enters responses, indicating where changes were made in the design documents, and returns them—either electronically or on a disk. The comments with the responses then become part of the Design Analysis for the next phase.

### *Barriers to Implementation and Solutions*

The manner in which Omaha District is set up to work on the network with ARMS has caused some problems with reviewers losing comments. We do have a backup file that comments feed into when a reviewer leaves PCARMS, and the file can be used to retrieve comments if they are lost—sometimes. We have PCARMS set up the way Sacramento was instructing us to when we first started working on the network, and their instructions are now different. Instead of having all the reviewers in one file out on the network as we do, Sacramento now has them working off their individual PCs and only using the network to

upload their comments after they have finished them. I believe this is probably better, and when I am asked about setting PCARMS up on a network, I send instructions for working both ways but suggest using the method Sacramento is using now.

We have not been able to move away from "hard copies" of review comments as we had hoped. I went out to Fort Carson for a review conference in 1994. We took out limited copies of the review comments and a notebook computer, with the idea of having the comment projected from the computer screen to a wall. I was going to do the annotations. The notebook computer that we used did not seem to be able to project the comment clearly enough for about half of the reviewers to see it, so we defeated our purpose by having to read the comments. We moved to a better sized room for the conference the second day, and then the notebook computer gave us trouble, and having no backup, the reviewers ended up having to share the few hard copies of the comments that were available.

Omaha District's big push at the first user's conference in 1991 was to task the TCX (Technical Center of Expertise) with making the ARMSWord software, as it was called at that time, network compatible. This was done.

The Sacramento TXC personnel were at Omaha District to train personnel to work with ARMS in 1991, and those individuals who were trained were to become trainers. In actuality, I do the classes for the Technical Managers and the Reviewers, rather than the trainers; the reviewers who were trained by Sacramento could probably have answered questions initially. Unfortunately, by the time we had done beta testing on the network compatible ARMSWord and were actually using it, too much time had elapsed for the training to be meaningful.

The TMs also had problems, initially, with connectivity to the central computer. All that was available was Procomm, and access to it was limited to sharing a "hard" line with usually three other individuals, including the time keeper. We now have telnet capability and easy access since the TMs have been set up with a batch file that automatically feeds in their IP number, and moves them to the MRK41 computer at Kansas City, which we are currently using for ARMS.

At one time, annotations to the comments, usually made at a review conference, had to be done out on the central computer. This did not turn out to be a good situation; the TMs lost annotations if they did not leave the file often and "save." Consequently the TCX personnel were asked at our second ARMS Users' Conference to give us the ability to download a file for annotations, and that was accomplished.

We have not had that much "push" from higher Headquarters recently on using ARMS and, when that happens, it seems that any problem will be used as an excuse not to use ARMS. The number of Military projects are down considerably for this fiscal year, although they are supposed to be up again in 1997.

### *Future Direction*

At Omaha District, the PCARMS software that is loaded on the Engineering Division network is DOS based. We have done beta testing on the PCARMS for Windows software that Sacramento District has developed, and now that the software is ready for use (December 1995), it has been loaded on our network and the reviewers will be offered a choice of working with either the DOS or Windows version.

Although we have the PCARMS software on the Engineering Division Network at Omaha District, Drew Anderson has worked to make it possible for individuals from other networks to access Engineering Division Network and make comments. In addition to Design Branch, we have input from reviewers in Construction Division, Planning Division, Environmental Branch, Geotech Branch, etc.

I am excited about the direction PCARMS has gone where Windows is concerned. It seems that our technical managers may be more receptive to using ARMS through Windows than the DOS-based version. One reason for this is that it is easier when they are already working in Windows not to have to leave the application.

## Omaha District's Plans for Using Electronic Bid Documents

by Drew Anderson[9]

### *Concept*

(a) Programs and Project Management (PPM) would create a new project in the Electronic Contract Bid Management System (ECBMS).
(b) Include information such as the Standard Industrial Classification (SIC), description, and dates.

### *90% Review*

(a) Engineering would prepare bid documents using Adobe Acrobat software for text documents and CALS format for drawings and load them into ECBMS. (CALS is DOD standard for raster drawings.)
(b) ECBMS will require a file description of each file placed in the directories. This information will be used to create a Table of Contents.
(c) Reviewers could view plans and specs either on-line or via CDs.
(d) Contracting would review the front end specifications.

### *Final*

Engineering and Contracting would update their bid documents in ECBMS.

### *Advance Notice to Bidders*

(a) Specifications sends Contracting the CBD announcements.
(b) Contracting will mark the project for "Advance Notice to Bidders".
(c) The Web Site will then show the project but not allow contractors to download files.
(d) The Central Web Site would be updated.

### *Authority To Advertise*

(a) PPM informs Contracting that authority to advertise has been given by the user.
(b) Contracting updates ECBMS.
(c) Electronic Bid Documents would be made Read/Only.
(d) Bid Packages would be sent to registered bidders.
(e) The Web site would now show the project as active.
(f) The Central Web site at WES would be updated.
(g) Files would be copied to the FTP site for download.

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### *Amendment*

(a) Specifications would issue an amendment to Contracting.
(b) Contracting would e-mail the amendment to all registered bidders. (Need to verify that the bidder received the amendment)
(c) Amendments would be e-mailed to all registered bidders. (Anyone ordering a CD after amendments have been issued would receive e-mail about those amendments.)

### *Bid Opening*

(a) Contracting indicates that bids are being accepted.
(b) FTP Server IDs are enabled.

### *Bid Closing*

(a) FTP Server IDs are disabled.
(b) Contracting would gather bids from the FTP server and prepare results.

### *Award*

(a) Contracting would input the bid results in ECBMS.
(b) The Web Site would display these results.
(c) The Central Web site at WES would be updated.
(d) Bidders would be e-mailed bid results.

### *Construction*

PMs, TMs, CADD, Specs, Construction, and Contracting will place documents that pertain to the project in ECBMS. (Need an SOP on what documents should be stored and in what format.)

### *Final payment*

(a) Contracting closes out the project.
(b) CDs will be created and sent to Contracting, Construction, Engineering, and the customer.

## Omaha District's Lessons-Learned Process

by Drew Anderson

### *Organizational Context*

Process primarily involves Engineering and Construction Divisions (approximately 600 people). Process is available and is used on virtually every construction project.

### *System Description*

DEFINITIONS:

Lesson Learned—A systemic problem with specifications which caused modifications to contracts.

Project Comment—A unique problem with a specification or drawing which may cause a modification to a contract.

PURPOSE: The purpose of this process is to constantly improve the specifications.

PROCEDURE: Lessons learned must be written and sent to the lessons-learned coordinator for electronic entry into system to database on LAN. The lessons-learned coordinator reviews entry and determines if entry is a true lesson learned or if the problem should be corrected by another means (comment to project, memorandum to Division, Suggestion program, etc.). If entry is valid, coordinator routes the specification problem to respective Engineering Division technical section for review and recommendation. Technical section reviews specification problem and determines if problem is Omaha District Only or Corps of Engineers (COE) problem. If only Omaha District, specification problem is corrected on SPECNET (Local type Specintact) and coordinator is notified specification has been corrected. If specification problem is COE wide, a DD3078 is prepared and sent through channels to correct COE specifications and notifies the lessons-learned coordinator. When a lesson learned is corrected or determined not valid any more, the lesson learned is removed from the database.

CRITICAL FEATURES:

1. Maximum access and simplicity for status of lesson learned.
2. Database must grow and shrink to remain effective.

### *Evaluation Criteria*

Evaluation measures are not used due to the costs of maintaining. Effectiveness is measured by reducing the number of repetitive modifications.

### *System Critique*

Process is very efficient and works well for the time being. Source code for the database is very old and is having some problems with the newer operating systems.

### *Future Direction*

Database needs to be upgraded with a better search engine and brought up to current operating level (Windows level). Budget is tight so it is hoped to find a similar database program and modify it slightly; perhaps "Reviewer Assistant System."

## Mobile District's Lessons-Learned Page

by E. William East

Mobile District's representative could not attend the workshop. The District has been very active in the area of lessons learned. For more information on Mobile's contribution, a link to their work is provided on the Design Review Tools Steering Committee homepage at http://www.cecer.army.mil/pl/ra/committee.

## Perspectives on Lessons-Learned Systems From South Atlantic Division

by Johnny M. Baggette[10]

Lessons Learned (LL) is a subject dear to my heart. I think this is the key to improving the quality of our designs. The first thing I would like to do is define LL for this paper. The term is often used for various types of feedback. For my purposes, it is feedback on the quality of a project under construction. An example would be the discovery during construction that criteria such as a guide specification is out of date and caused a construction change. The LL would define the problem and suggest a solution. The LL System (LLS) would be a repository for these LLs until the specification is corrected. In this case, someone would fill out an ENG Form 3078 and submit it to USACE for correction of the specification.

The key to a useful LLS is a system that is simple to use and is kept up to date. The Mobile District is using such a system, based on a system originally developed by the Omaha District. They have taken the system and made it available through a Home Page on the Internet. If all Districts had such a simple system, and a central Home Page were developed for all the Corps, we could have a truly simple and useful LLS. The central system could access the individual district systems in a transparent fashion to the user.

To continue to be useful, an LLS must be used to make corrections to our criteria, and then they must be removed from the LLS. The other thing that must happen is continuous input of new LLs. This can be encouraged by making sure the people that put LLs into the system get feedback when corrections are made. I see this as a key to making the system work in the long term.

If the Corps develops a central system, it must be simple as described above and must not add a burden on the Districts. The Districts will want to use a simple system that offers good LLs and doesn't cost them to support it, except for the time within their District to keep their individual system up to date. This valuable tool should be developed and made available as soon as possible with future expansion until all Districts are participants. These are just some thoughts I have and a summary of my experience on this subject. I stand ready to assist with the development of such a system in whatever capacity is appropriate.

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## BCO Reviews at Portland District

by Joseph B. Russell[11]

### *Organizational Context*

The number of personnel involved in the BCOE process within the District is approximately 225 personnel. This number includes Engineering Division, Operations Division, and Construction Division.

Ineffectiveness was commonplace with old methods due primarily to the hard-copy format that the District was using. Inefficiencies were due in part to the uncertainty of the status of follow-up actions. The designers contacted the individual reviewer independently to discuss the comments. This made it hard to identify whether comments had been incorporated within the final bid documents. Field office concerns were left unresolved in many cases. This created frustration and discontent with the process.

### *System Description*

Portland District is using Microsoft Office Software for forms assembly and CCMail for electronic mail messaging and document transfers for the BCOE Review Process.

### *Evaluation Criteria*

Management measures used to evaluate the successfulness of the previous and current systems are unknown. At the present time the efforts have been bottom driven based on concerns from the field offices and people who have moved from the field office back into Construction Services Branch to initiate some revisions.

### *System Critique*

The electronic form of the NPD Form 32 was developed by a Construction Division POC at first in Microsoft Word. The BCOE comments are transmitted from field offices by electronic mail as an attachment file. Files are imported into a master document and critiqued by the Construction Division POC prior to forwarding to the Engineering Technical Manager. The ability to sort comments based on spec sections or drawing reference numbers is nearly nonexistent in Word. Microsoft Excel® is now being considered to accomplish this since it does have a sorting capability.

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### *Future Directions*

A more efficient way to store and retrieve this information is obviously a database format. This is true since specific parameters for importing, sorting, editing, exporting, storing, and retrieving can be utilized to maximize the efficiency. We are pursuing development of a database system which replicates the NPD Form 32 at the input screen.

# 5 Products To Support Design Reviewers and ARMS

## The Reviewer's Assistant and Lessons-Learned Generator

by E. William East and Michael C. Fu[12]

Design reviews attempt to discover and eliminate potential problems that may be encountered during the construction and operation of a facility. The characteristics of many projects suggest that design reviews are necessary for ensuring a balance among the various, conflicting requirements of many projects [O'Connor 1986]. Some of the many aspects that need to be considered during a design review include: (1) biddability, (2) constructibility, (3) operability, (4) technical reviews, and (5) customer reviews.

The biddability component of a design review attempts to determine "the ease with which the contract documents can be understood, bid, administered and enforced" [Kirby 1988]. Constructibility effects refer to the "compatibility of the design with the site, methods, materials, and schedules" [Kirby 1988]. Constructibility problems may result in "schedule delays, safety detriment, structural deficiencies, additional labor costs and contract disputes" [Hancher and Lutz 1988]. Operability reviews may find items that, if not resolved, could result in "facility disruption, diminished habitability, excessive maintenance, safety detriment, energy inefficiency, structural deficiency, and system replacement" [Hancher and Lutz 1988]. Specific technical reviews are also conducted to ensure compliance with initial and design calculations, building codes and interfaces between disciplines [USACOE 1987]. Customer reviews may be conducted to ensure that the user's functional requirements are included in a project. Other examples of design review types include historical preservation reviews and environmental sustainability reviews.

Given the complexity and geographic distances involved in efficiently conducting design reviews, the U.S. Army Corps of Engineers has developed an automated system for the support of the design review process called the Automated Review Management System (ARMS) [Kirby 1987]. The process is shown in Figure 1. Project managers request that reviews be conducted based on design submittals received from Architect/Engineer (A/E) firms. Review managers identify specific reviewers who then conduct reviews and transmit their comments to the A/E firm for resolution. The ARMS system is required for use on the U.S. Army, Corps of Engineers, Military Construction Program Projects [HQUSACE 1993].

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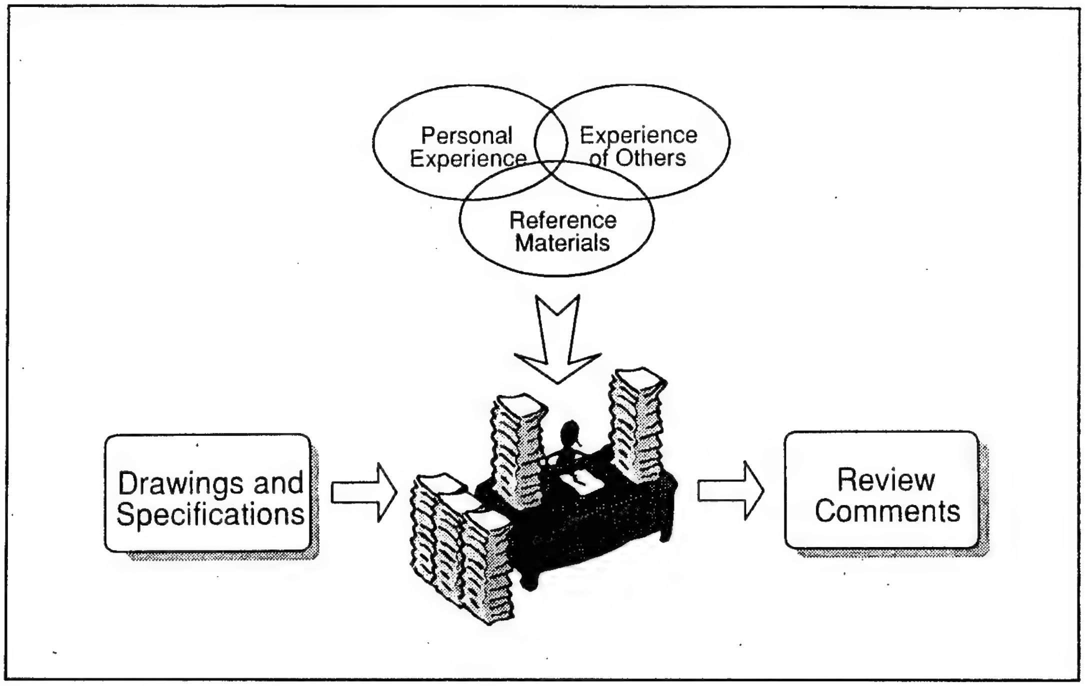


**Figure 1. Model of review comment preparation.**

Data in ARMS are stored in an Oracle database operating on mini-computers running the UNIX operating system. There are DOS and Windows shells for typing comments into the standard ARMS uploading format. The uploading format is an ASCII file with a combination of fixed field and period delimited data elements. The format is often referred to as a "CMT" file since the file name extension of "cmt" is used for a correctly formatted ASCII file. Other systems supporting ARMS may also use the CMT format to transmit data to ARMS.

The Reviewer's Assistant is a system developed at the U.S. Army Construction Engineering Research Laboratories (USACERL) to assist the design reviewer in capturing and appropriately reusing their design review experience [East 1995a]. Copies of the system have been made available to over 500 governmental organizations and private companies for testing [ASCE 1995; McGraw-Hill 1996; NASA 1996].

Reviewers prepared design review comments used as the basis for the Reviewer's Assistant System. A reviewer critiques plans and specifications according to the reviewer's expertise, the experience of others, and the use of appropriate reference tools. The reviewer's mental evaluation of the plans and specifications is translated into a set of design review comments. This set of comments is then transmitted either electronically to the ARMS system or printed and mailed to the appropriate party.

As the Reviewer's Assistant is used, there will be an increasing number of projects stored in the system's database. During one fiscal year, for example, several hundred projects may be reviewed by a given reviewer. Searching

through a potentially large set of comments will, over time, become cumbersome for the user and slow due to the increasing size of the database. A method is needed for easily accessing sets of highly useful review comments, so that reviewers may efficiently find reusable comments.

Making sense of the large and ever increasing amount of information contained in databases is often referred to as "data mining." The interest in integrating the ability to discover patterns in large databases, a subset of machine-learning technology, is expected to increase as organizations find themselves with ever larger amounts of data and less time to evaluate that data [Michie 1990]. Interest is also increasing in the area of knowledge discovery in databases by many researchers [Silberschatz 1990].

Owners have attempted to transmit lessons learned from construction to design through the use of standalone paper or automated checklists. Due to the limited time available to complete the hundreds of design reviews conducted each year, reviewers can not practically spend the time needed to access and maintain these standalone systems. In the author's opinion, for lessons learned to be fully applied, they must be available as reviewers compose their design review comments. The authors were interested in exploring the extent to which lessons learned could be abstracted directly from a practical comment composition system such as the Reviewer's Assistant.

The following section of this paper is a brief overview of the Reviewer's Assistant. A complete discussion of the system may be found in East [1995b]. The next section discusses the issue of quality in reviews and propose a simple algorithm for discovering comments of high quality. The third section contains a run of the Lessons-Learned Generator on a sample database. The results of the sample run demonstrate problems with the current approach that are discussed in the final section of the paper.

### *The Reviewer's Assistant*

The Reviewer's Assistant integrates a relational database system, a text editor, and communications software into a seamless sequence of reviewer-computer interactions designed to support the design review process. The Reviewer's Assistant contains two models of user interaction. In the "novice mode," which is the default start-up mode, users are guided through a series of simple steps that allow the most efficient creation and distribution of design review comments. As users become more familiar with the program, however, they may want to follow a different set of steps than is in the "novice mode." In the "expert mode," more experienced users may select operations to be performed based on their understanding of the program and the task at hand. Access to data in the "expert mode" is available through "pull-down" menus.

The "novice mode" is built upon the premise that reviewer's primary interest is in completing the design review, and not in learning new software to help them perform design reviews. As a result, the "novice mode" follows the steps that reviewers typically take when performing design reviews. Specifically, the

"novice mode" user interaction follow these steps: (1) the reviewer selects their name from the set of all reviewers known to the system, (2) a new review project or an existing review project is selected, (3) a brief set of general information about that project is collected for new projects or confirmed for existing projects, (4) users may begin creating comments, (5) during the comment authoring process, the reviewer may "pop-out" to a search mode to find past comments related to specific topics of interest, (6) searched comments that are edited will be included in the current design review, unedited comments are discarded as not applicable, and (7) a review is completed and comments are forwarded to a printer or via modem to the ARMS system using a CMT file [East 1994].

One important concern that was raised and addressed during the development of the search routines is that of copying standard sets of comments to all projects —the electronic equivalent of using photocopying equipment to create a design review. In the Reviewer's Assistant, comments identified by a search are not automatically applied to a given design review. Users must select those comments by individually editing each comment that applies to the project. The user need not change the comment text, however, the mandatory indices, for specification section and design discipline, must contain values. Those comments that are not edited may be "dumped" from the list at any time. Any remaining unedited comments are automatically removed prior to printing the list of comments for the project.

Within its relational database, the Reviewer's Assistant maintains each comment for every review. Each comment is uniquely identified with a combination of project number, comment number, and comment text note number. Each comment is linked with indexing information corresponding to the content of the comment and its context in the design review process contained in other tables. Searching using these indices allows reviewers to easily apply expertise from past projects.

The most important of the indices that describe comment content are "Feature/ Value" combinations. The Feature/Value combinations initially provided with the system are organized according to the standard Construction Specification Institute (CSI) breakdown [CSI 1988]. Figure 2 shows an example of the tree structure used to display the Feature/Value pairs. The Reviewer's Assistant initially comes with the top-level Feature set to "Specification Sections," and Values set to the specification paragraphs under the specification section. The combination of Features and Values describes the kind(s) of work to which the review comment is related.

During the initial set-up of the program, the Feature/Value tree may be modified to reflect any type of project. Nested sets of Features may be created to model complex types of indices. Each of the Features may contain associated Values; however, the typical situation is that the Values are at the lowest level of a set of nested Features.

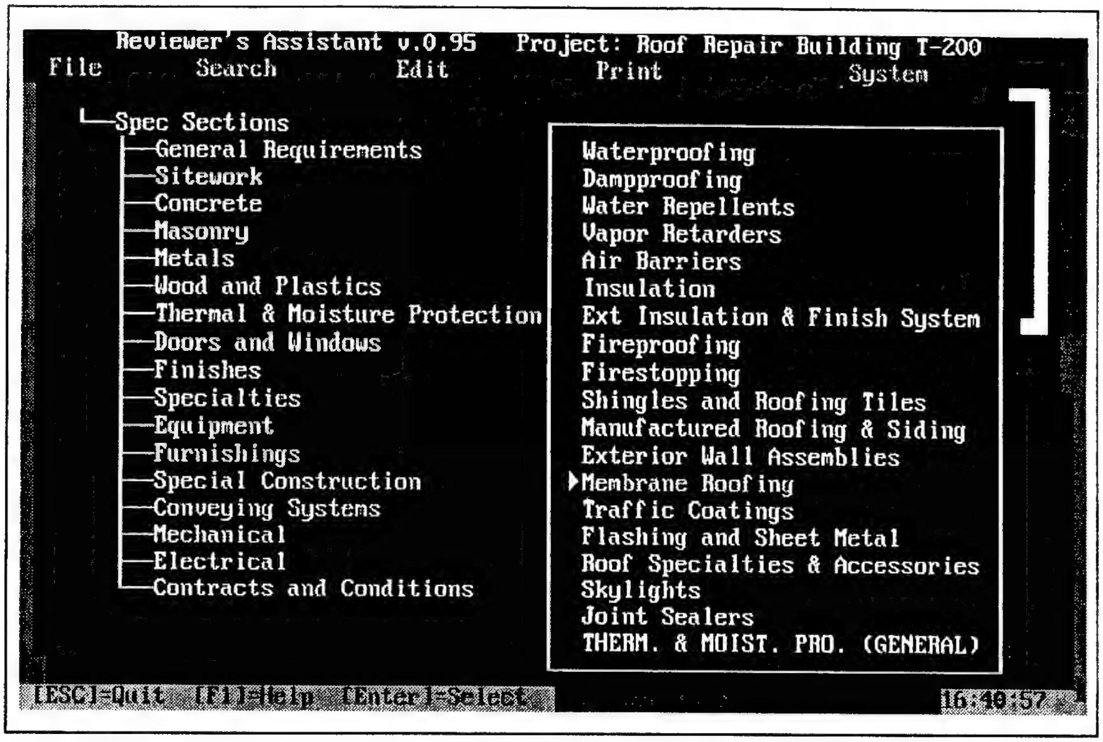


**Figure 2. Feature/value pairs.**

The edit screen, shown in Figure 3, is where comments are created and indices are linked to each comment instance. The text in the center of Figure 4 is the instance of the comment currently being edited. The Function key [F3] allows users to edit the project specific location of the comment. Function key [F4] allows users to edit the Feature/Value pairs for the comment. The Function keys [F5]-[F8] allow users to select Perspectives for the comment. Pressing [F9] allows users to modify the set of keywords associated with the current comment.

In Figure 3, the Feature selected is "Thermal and Moisture Protection," and its Values are "Waterproofing," "Dampproofing," "Water Repellents," "Vapor Retarders," etc. Since the content of the comment may refer to a number of different Specification Sections, the Reviewer's Assistant allows any number of Feature/Value combinations to be linked to the comment.

Another form of indexing information are the "Perspectives." While Feature/Value pairs identify comment content, Perspectives identify the comment's context. Four types of Perspectives are initially provided in the Reviewer's Assistant: "Design Discipline," "Review Type," "Site Criteria," and "Reviewer."

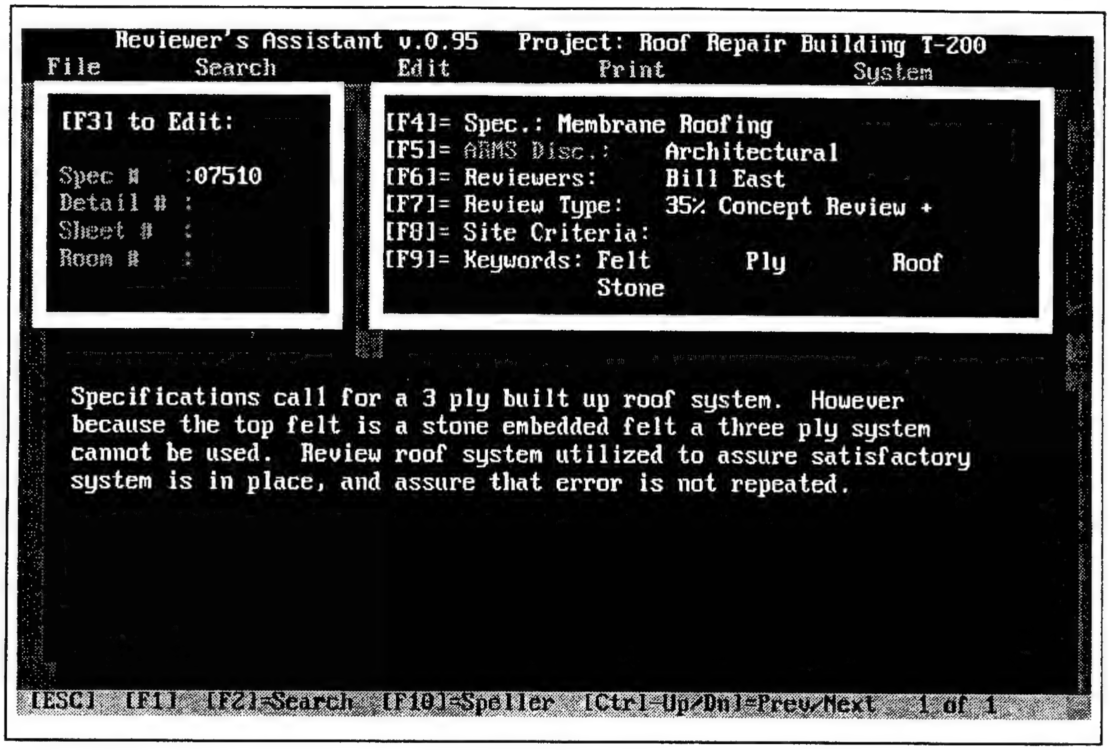


**Figure 3. The comment edit screen.**

As shown in Figure 3, Perspectives are identified in the upper righthand portion of the comment edit screen under the function keys [F5], [F6], [F7], and [F8] respectively. The Design Discipline Perspective allows the identification for the field of expertise of the firm that should evaluate the comment. Examples of Design Disciplines are "Mechanical," "Structural," and "Architectural." Design Discipline could also be used as address information by including the name of the consultant who should evaluate the item in question.

The Review Type Perspective is used to identify the timing of the comment in the review process. This is important because the specificity of comments varies as the design progresses. At the start of a design, for example, comments of a more general nature are typically encountered. The Review Type may be used to distinguish between concept and final design reviews to allow searching on the correct level of detail.

The Site Criteria Perspective may be used to identify various information regarding the overall project, for example, geographical location or customer name. The Reviewer Perspective provides an index for the name of the person conducting the review. Although the set of Perspectives is initially set in the Reviewer's Assistant, both the names and the contents of all of the Perspectives may be changed. For example, the Site Criteria Perspective may be changed to "Customer Criteria" and used to track items of interest to specific customers.

The third category of indexing information is "Keywords." The Reviewer's Assistant contains over 2,000 construction related keywords. Programming also identifies the plural forms of these keywords. Reviewers may link up to six

keywords to a review comment. As shown in Figure 3, Keywords are linked to each comment under the function key [F9] in the upper righthand box of the comment edit screen.

### Discovering and Abstracting High Quality Comments

As of Fall 1992, the ARMS "Central" site contained over three million design review comments, primarily from a single Corps of Engineers District. The ARMS system has become more decentralized since 1992 and each local ARMS server system will accumulate comments at a rapid rate as more reviews are completed. This review comment population explosion will create severe problems for reviewers performing searches for previously created comments. As the number of comments in the system increases, a search of the database will yield an increasing number of comments of varying degrees of usefulness to the reviewer. Without some notion of quality to order the retrieved information or to constrain the search, the reviewer is forced to examine all of the retrieved comments arbitrarily to find the comments that apply to the particular project at hand.

#### *Defining High Quality Comments*

Quality in review comments may be measured by three metrics: usefulness, generality, and content stability. Usefulness refers to the actual content of the comment; it measures how well a problem and its solution are described and the salience of the problem/solution to the design review process. Generality refers to the applicability of the comment across projects. Many design review comments are specific to a single or a small set of projects. While these types of comments may be very useful to their parent projects, the applicability of comments that are very project-specific to future projects is often limited. Of course, a comment cannot be so general as to lack sufficient context to describe what must be done. Below are several examples of comments that are not well formed:

> The design team shall consult with the Base Civil Engineering Office to review the installation's program of architectural compatibility. The design team shall be sensitive to the cultural, architectural, and environmental influences that affect the installation and the particular site proposed for the project.
>
> The visual design of the project should be in harmony with its surrounding.
>
> Secure rooms and vaults have bars in ducts.
> Detail C on sheet A-7 does not clearly show how or if the cab glazing units are anchored at the jambs.

An example of a comment that is of high quality is provided below. The example comment explains the current situation, the rationale explaining the potential problem, and contains a possible remedy for the situation based on the reviewer's knowledge.

> The specification indicates copper roof pan lengths to be approximately 45' long. The Copper Development Association recommends 30' maximum pan lengths, especially in northern tier climates. Copper expands 1/8" per 10' for every 100 °F of temperature change. The 45' long pans with expansion cleats are theoretically possible, but not practicable during installation.

Content stability is the third concern. As comments are copied from project to project, reviewers may alter the contents of the comment, thus causing "content shift." Comments experiencing severe content shift cannot be abstracted, since it is unclear what the meaning of the comment has become.

*Abstracting High Quality Comments*

The Lessons-Learned Generator finds and abstracts high quality comments by observing the patterns of comment reuse by reviewers. This approach is valid for two reasons. The first is that there is a historical precedent for comment reuse. Paper sets of repetitive deficiency lists are frequently developed in all agencies. The idea of problems recurring and needing to be fixed is a common theme in most design reviews. The second is simply that people would rather reuse well-formed, on-point comments that are "tried and true" rather than start from scratch to create a well-formed comment.

As reviews are conducted, those comments that are well-formed and on-point for a particular situation will tend to be selected under similar situations in the future. Those comments that are too vague or too general will not be used again. High quality comments are those comments that reviewers search for, find useful and use again and again on their current project. Based on this definition, we can assert that high quality comments will have more than a singular, or infrequent, existence in the comment database.

The Lessons-Learned Generator discovers and represents these patterns of comment usage in a two-phase process. First, a comment frequency threshold is calculated from the existing Reviewer's Assistant database. Comments whose frequency exceed this threshold are hypothesized as high quality comments. The second phase involves a closer examination of those hypothesized comments. The content of the comment is analyzed for commonalties using the indexing information linked to every instance of the comment. If there are sufficient commonalities in the indexing information, then it is assumed that content shift has not occurred, and the comment is abstracted to a new project called "Lessons-Learned Comments." The Lessons-Learned Generator has several heuristics to judge whether a comment has experienced content shift.

*The Lessons-Learned Generator Algorithm*

To illustrate the algorithm, consider a sample database containing five projects and five comments shown below. When we look at the set of comments for the five projects, the first three comments have only been used once on individual projects. The fourth comment was created during the review of the first project and subsequently copied to each of the other four projects. The last comment in

the example database was created on a project and applied to two subsequent projects. In the Reviewer's Assistant, information of this type may be drawn from the relational database structure since comment text is identified by both a comment number and an instance number.

| Comment Number | Number of Instances |
|---|---|
| 1 | 1 |
| 2 | 1 |
| 3 | 1 |
| 4 | 5 |
| 5 | 3 |

Phase 1: Calculating a comment frequency threshold

The lessons-learned generator begins by determining a "frequency threshold" to compare the amount of reuse in the database that is being evaluated A table of comment frequencies, with each entry in the table corresponding to the number of times a particular comment is developed for every comment in the database. This is done by counting the number of comment text records ("notes") associated with each unique comment identification number.

Next, the expected comment frequency is calculated. This average comment frequency is the threshold that will be used to evaluate frequently reused comments. For the above example, the comment frequency threshold value is: $(1/5) * (1 + 1 + 1 + 5 + 3) = (1/5) * 11 = 2.2$. Comments Four and Five, whose frequencies exceed 2.2, are evaluated in the abstraction phase.

Phase 2: Abstracting the Selected Comments

For each comment whose frequency is greater than the threshold, all instances of the comment are found and the associated index information is evaluated. The objective of gathering this information is to determine the commonalties, or "conditional attributes," for the comment [Zairko 1991]. In our sample database, Comment Five has three instances; suppose that the instances have the Feature/Value pairs associated with them as shown below.

Instance 1:
Thermal and Moisture Protection/Waterproofing
Thermal and Moisture Protection/Water Repellents

Instance 2:
Thermal and Moisture Protection/Waterproofing
Doors and Windows/Metal Doors and Windows

Instance 3:
Thermal and Moisture Protection/Waterproofing
Thermal and Moisture Protection/Dampproofing

The first instance of Comment Five, for example, has two Feature/Value links. The first is to the Thermal and Moisture Protection Feature with a value of Waterproofing. The first instance of Comment Five also is linked to another Feature/Value pair, Thermal and Moisture Protection/Water Repellents.

The intersection of the Feature/Value combinations of the three sets is computed. In this case, only a single Feature/Value combination exists in all three instances: Thermal and Moisture Protection/Waterproofing. This particular Feature/Value combination becomes a conditional attribute for Comment Five. An identical operation is performed on the perspectives and keywords.

Both Keywords and Feature/Values are critical conditional attributes in determining the content of a comment. The comment's instances must have at least one element both in the intersection of the instances' keyword sets and in the intersection of the instances' Feature/Value combination sets. The algorithm interprets a null intersection set for either type of index information as a set of comments that have undergone some type of content shift. As a result of this shift the specific instances of the comment are not abstractable to a single comment.

An abstracted comment is a combination of the comment text and the condition attributes created by the index information analysis. Each abstracted comment is saved in a new project within the Reviewer's Assistant database. All other instances of the comment are deleted. Reviewers searching the lessons-learned database can access the information that was retained most frequently before having to sift through the results of a full, unordered search through the projects. The lessons-learned database may also serve as a back-check for design reviewers and as a learning tool for novice review personnel.

### *A Sample Run of the Lessons-Learned Generator*

To illustrate the Lessons-Learned Generator, we created a small test bed consisting of five reviews in the domain of roofing systems. The reviews were distributed across copper roofs and shingle-asphalt roofs. For each project, searches obtained comments from previous projects, and new comments pertaining to the specific design were added.

Figure 4 is the screen that the Lessons-Learned Generator displays after the frequency threshold calculation phase. The comment frequencies have been tabulated and the frequency threshold has been computed.

After the abstraction process, the Lessons-Learned Generator displays the final screen of statistics. Figure 5 shows that, of the 18 comments thought to be significant, six were actually extracted. The comments that were not abstracted exhibited comment shift.

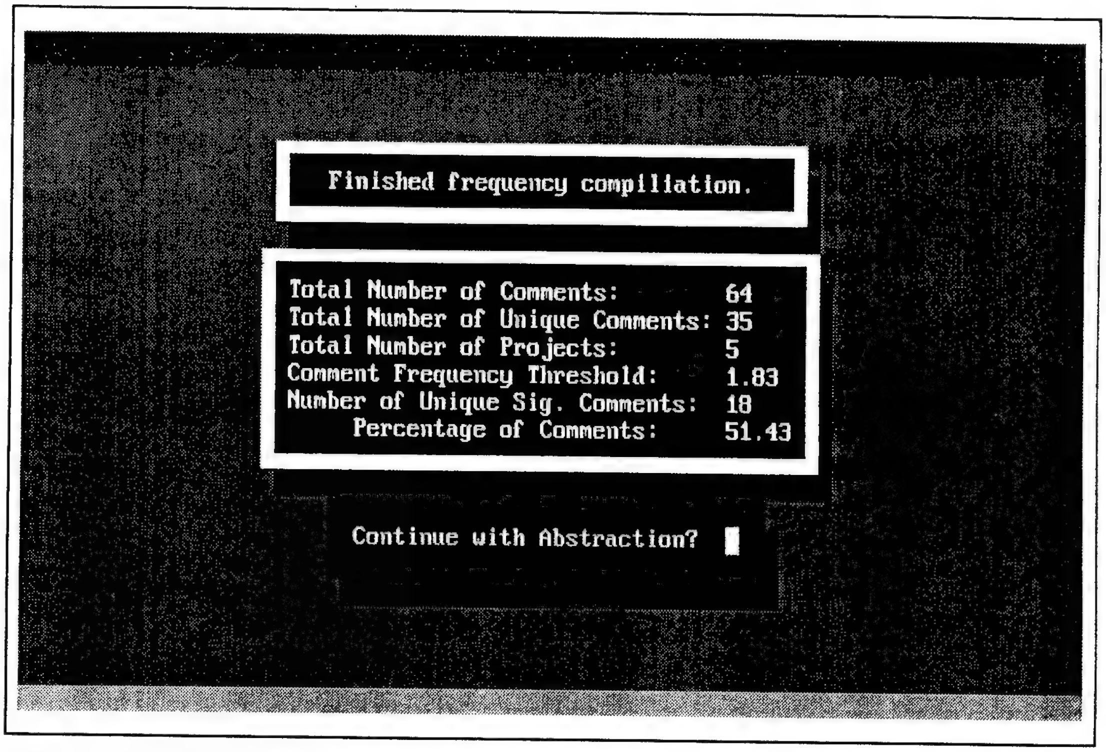


**Figure 4. Results of the frequency threshold evaluation phase.**

### *Recommended Improvements*

The Reviewer's Assistant is currently being tested by members of design, construction, and owner communities. As a result, large databases of real reviews created over a period of time do not yet exist. As these databases become available, the authors will be better able to assess the performance of the Lessons-Learned Generator. However, even the small test discussed in this paper demonstrates future areas of improvement and research.

One area of improvement is that of the abstraction heuristics, specifically the deciding of the conditional attributes and the determination of content shift. The current algorithm assumes that, as reviewers modify their comments, they modify the index information linked to the comment. As this may not always be the case, it would be useful to enforce the re-examination of the index information when content shift is detected. A good detection measure would include analysis of the index information that was changed, and perhaps an examination of the text of the comment itself. Another means would be to conduct a keyword analysis of each comment and determine if the order of all keywords in the comment was consistent with the instance of the comment originally copied to the project following a search.

Allowing the program to check keywords just prior to exiting the comment edit screen would require a very small modification to the Reviewer's Assistant system. The change could also be performed so that the user would not be burdened with the burdensome overhead of manually verifying comment's indices.

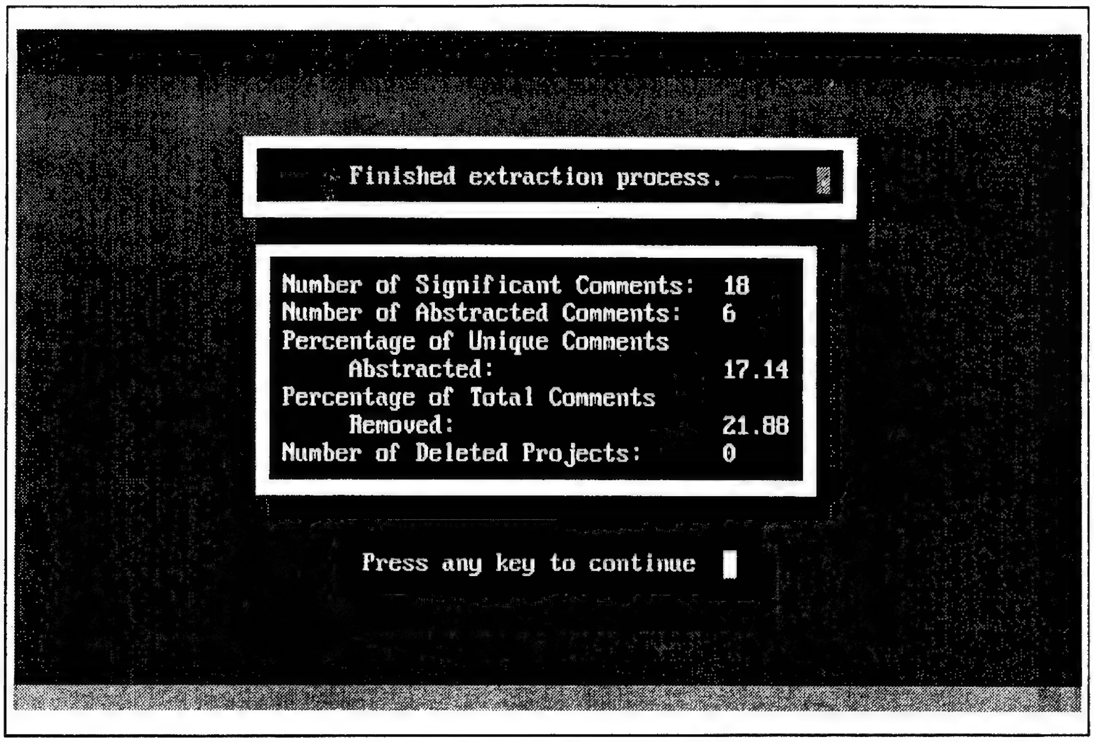


**Figure 5. Results of the extraction phase.**

A maximum of two programmer weeks would be required to implement such a change.

The current method used to calculate the frequency threshold may be fooled by unexpected comment frequency distributions. For example, if there are only a few unique comments in the database when the Lessons-Learned Generator is run, a small group of comments with very high frequencies may push the frequency threshold beyond the frequencies of other important comments. As a result, only the comments from the very high frequency group are examined for abstraction by the generator while equally good "lessons learned" may not be considered.

Another situation that causes the current algorithm to act in an unexpected way is the case where a comment has exceeded the frequency threshold, and there is not a single common conditional attribute across all instances. For example, a comment with 51 instances where the last instance has exactly the same text but all the conditional attributes have been changed. Since the lessons-learned algorithm, which is searching for the set of attributes that are in common among all instances of a comment, finds not a single common attribute, the candidate comment will be eliminated from further consideration.

Having one comment with a completely different set of attributes out of a large set of similar comments is unlikely, since users will naturally limit changes to comment indices, which the user perceives as extra work. Currently, there are two approaches to solving this problem. The first is to use keywords which, as noted previously, is a more accurate method of determining if attributes are changed. The second method would be to develop a "noise" threshold. This

threshold would allow a few pieces of inconsistent data to be removed from the evaluation process.

Two approaches to setting a noise threshold have been suggested. An empirical method would ignore comments with dissimilar attributes if the number of comments was less than a statistically or user-provided threshold. Another approach that could be implemented would eliminate noisy comments after those comments have remained in the database for longer than a user-defined duration.

To evaluate the possibility of unexpected frequency distributions, detailed analysis of large databases containing design review comments will be needed. One author has suggested that a database of approximately 1,000 items is required prior to effectively testing an algorithm of this type [Frawley 1991]. Individuals using the Reviewer's Assistant are asked to contact the authors so that large databases of comments may be tested.

Some have suggested that a possible side benefit of the Lessons-Learned Generator, that has not been fully explored, may be in the use of comment frequency information and the comment creation date to cull obsolete comments from the database. Currently, the recommended way to remove unneeded comments is to delete entire projects or to delete individual comment instances after saving projects in CMT files or backing up the entire database.

While the Lessons-Learned System may be considered a simple type of "unsupervised" learning system, some authors have suggested that user interaction would improve the performance of this type of algorithm. For example, frequency thresholds may be fine tuned with user interaction or subsequent analysis [Cai et al. 1991].

Further evaluation of the conditional attributes should also be considered. For example, if all instances of a comment have the same attributes, a possible generalizing attribute may be created [Silverman 1991]. Conversely, conditional attributes may be specialized to only a very small subset of indices. These attributes may even be considered as antecedents of rule sets that determine when specific comments may be applied through an expert-system mode of interaction.

In developing the Lessons-Learned Generator, the authors were limited in their abilities to represent design review comments by the indices included in the Reviewer's Assistant system. Since all representations are limited, the authors' interest was not to develop an enhanced representation of lessons learned but to investigate the extraction of useful lessons learned from a practical relational database system. Application of "data mining" techniques could surely be improved if the representation of the design review comments was extended beyond the simple relational model.

### Conclusion

The Lessons-Learned Generator is a demonstration program that works in the context of the Reviewer's Assistant system to abstract a set of high quality comments from a large set of reviews. Quality is defined in terms of usefulness, generality/specificity, and content stability. A high quality comment is one which addresses an important problem and is clearly and concisely written. The algorithm used by the Generator relies on patterns of reviewer usage to determine the quality of comments.

Most reviewers do not have time to access standalone repetitive deficiency checklists. Data-mining tools, operating within existing corporate automation systems, allow users to access lessons learned during the course of normal business practices. Use of these lessons learned is an important factor in reducing the life-cycle cost of construction.

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## Checking Codes and Standards

by Carl Mileff, CMA & Associates

Plan review involves using and applying a large amount of information. For example, here is a list of codes and standards routinely used in plan check: building, mechanical, plumbing and electrical codes; fire codes and related NFPA Standards; state and local ordinances and code amendments; building and industry construction and material standards; engineering and structural references, calculations; code interpretations, publications, personal notes and diagrams; and in-house standard forms and checklists.

For the most part, this data is in paper form, voluminous, and very difficult to organize and correlate. It amounts to a lot of information to be searched, analyzed, and applied. How well this data is organized and made available has a direct impact on the ability of reviewers to do their work quickly and accurately.

### *Plan Review Approach*

One method that we use to maintain speed and accuracy is "combination review," where each plan checker reviews and manages the review of each job from start to finish, covering all disciplines in one session. This offers benefits: faster reviews, continuity, self-training, versatility, and increasing capabilities. It has its problems as well. Needed information has to be quickly available, usable, and in easily communicated form.

With pressures to produce, we continue to experiment with different text-based methods to perform reviews and create correction reports: standard comments; checklists; barcode comments; macros; like-project reports. While helpful, these methods prove less than adequate. In every case, reviewers spend most of their time editing and scrolling through unneeded information to find applicable data and create a report. We always wanted something better.

### *Plancheck Tools*

With a captive programmer (my son), we started the process of designing PlanCheck Tools in 1986. This was a personal experiment for my company that grew into a real product. The effort lacked many of the essential ingredients for success, but it was a valuable experience.

Simply, I wanted to be able to review a plan, turn pages with my left hand, and point and click on the computer with my right-handed mouse. I wanted to view the information I needed, create a report, print it, and send it to the designers. It would have the following basic features: repetitive comments could be standardized, saved and accessed; comments could be linked to codes to prevent arbitrary findings; we could store and link all kinds of information (codes, notes, pictures); we could organize information for different kinds of buildings; we could create, edit, and print a plan check report automatically.

As it developed, the program was organized into a hierarchy of topics and internal relationships: Group Search Panel by building types; Main & Sub Topics Reference Codes—all comments have five references; Comments—here comments are an output of knowledge; Notes & Diagrams; Checklists; Correction List Files; and Printed Reports.

Users could configure and input data and their linkages. Codes and other data could be searched by subject via the search panel or by keyword. All comments would be tied to reference codes to prevent arbitrary comments. A plan check file could be created and include project data and the added correction list comments. There would be editing functions and a printed report.

Filling in the database was a difficult and impossible task at the time. The code publishing organizations were reluctant to share their copyrighted material and were concerned about security. We received a limited license from ICBO to copy small portions of the UBC. The bulk of any necessary data had to be input by the user. This was a major drawback, since codes were essential to program operation.

### *Lessons Learned*

The following describes some of the lessons learned from the PlanCheck Tools programming project.

#### *Program Design*

Initially, the program was written under Microsoft Windows Version 1.0. This alone presented many difficult and complex technical problems. Documentation was scarce and technical support virtually nonexistent. We recognized early on that most users would not be familiar with Windows and would have to purchase new equipment to run the program. This resulted in users rejecting the system based on hardware costs alone. Also, many users were unfamiliar with Windows and were reluctant to retrain themselves or their staff. Basic reference code data and configurations were input into the program during development and testing; however, the very limited data proved inadequate to cover all possibilities and additional configuration by users proved too complicated and unworkable. Though it was the best we could come up with at the time, the linking of comments to reference codes was a mistake. Comments were the final product, yet you could not get to them except via the applicable reference code. Session files were another problem. Project data input was too cumbersome, editing too difficult, and the printed list was poorly structured and not of word processor quality. Output was one of the most critical problems and absolutely prevented practical usability of the program.

#### *Program Development*

After the initial design phase, many features continued to be added, mostly as "good ideas" or experiments. Indeed, features took precedence over usability as

design progressed. This prolonged the development cycle and eventually weakened the basic structure of the program. In retrospect, the feature list should have been frozen early on.

PlanCheck Tools was primarily designed to help a user build a correction list document. We also believed that once a user started inputting information into the system, that information could be used later to help identify common problems or indicate problems based on probability.

Users, however, were not interested in the long-range plans for the system and were confused by terms they were unfamiliar with. They needed to solve specific problems, and PlanCheck Tools was too rich with "complicated" features and others that just did not work very well.

The program was built to be very generic and user configurable. Again, this type of design means that the user has to do a lot of work. They were turned off by the prospect of too much configuration.

One of the biggest marketing obstacles was that the general market was not computer technical, and users were reluctant to work differently or wanted the system to do everything for them. One valuable lesson learned is that of the old cliché: "A chain is only as strong as its weakest link(s)." Finally, we ceased development in 1990 for a number of reasons. We hope to continue the effort at a future date.

# 6 Future Directions for Design Review Systems

## An Automated Design Review Assistant

by Michael C. Fu[13]

The Support Environment for Design And Review (SEDAR) is a graphical expert critiquing system for use by designers and reviewers of flat and low-slope roofs. SEDAR provides assistance during the design process through the use of its critiquing strategies (error prevention, error correction, and design review) and its design suggestion strategy. SEDAR better integrates the design-review process used by many Architect/Engineer (A/E) offices to ensure design quality.

SEDAR helps roof designers by providing critiques and suggestions as the design of the roof progresses using the error prevention, error correction, and design suggestion strategies. By providing feedback as design decisions are made, errors can be prevented or detected early in the design process. SEDAR helps design reviewers by checking the correctness of a design by using design codes stored in its knowledge base (the design review strategy). Since the process of design review is inherently a time-consuming and resource-constrained process, SEDAR will help reviewers by providing consistent and comprehensive reviews of the design using the design codes within its knowledge base. Use of SEDAR in the existing roof design process will help to reduce premature roof failures that are caused by poor quality designs. Roof failures resulting from errors and misjudgments in design constitute a serious legal threat to architects, contractors, and manufacturers alike (Griffin 1982) and result in high repair and maintenance costs to building owners.

SEDAR focuses the content of its critiques and suggestions through the use of functional decomposition of the roof design task called the Designer's Task Model (DTM). The DTM was created from observations of how experienced roof designers decompose the roof design task into interdependent subtasks associated with the layout of functional subsystems, such as the drainage system or the walkway system. SEDAR's focusing strategy uses the DTM to flexibly track the progress of roof designers so that SEDAR can provide the most relevant critiques at appropriate times in the design process. A prototype version of SEDAR has been implemented for personal computers running Microsoft® Windows using Goldworks III™, a LISP-based expert system shell, and AutoCAD™, a computer-assisted design (CAD) tool. The results of an evaluation of the system were that users had favorable reviews of the system,

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that SEDAR helped reduce the number of design errors, and that the functional decomposition of the DTM matched the users' conception of the roof design task.

### *The SEDAR Architecture*

The architecture of SEDAR is shown in Figure 1. The User Interface is the communication medium between the designer and SEDAR. The user may add, delete, or move design objects (e.g., roof drains, airhandling units, walkways, etc.), examine the state of the DTM, view the existing critiques on the design, and turn any of the critiquing strategies on or off. User actions are communicated to the Critic Management Agent, which selects a critiquing strategy to apply and updates the shared data structures on the Blackboard (specifically, the DTM and the design representation) to reflect the modification. It then activates the appropriate Critic Agents (here the Flat/Low-Slope Roof Agent), which perform the design analysis according to the selected critiquing strategy, and translates their results into graphical/textual critiques. The critiques are then sent back to the User Interface for display. This basic operating cycle is called the iterative critiquing cycle.

### *The Designer's Task Model*

The DTM is the central component of SEDAR and is used to guide automated support for both designers and reviewers. It is a hierarchy of possible design tasks that might be encountered by a user during a roof design. Figure 2 shows a portion of the DTM; the task at the left, RoofLayout, is the most abstract task. The leaf nodes of the hierarchy, for example, Drain-Layout, WalkwayLayout, etc., represent the design of specific functional subsystems. Part-of links, shown as solid lines in Figure 2, describe the task-subtask relationships. Before-task links are precedence relations between tasks observed from human expert behavior. Interferes-with links represent possible interference among tasks.

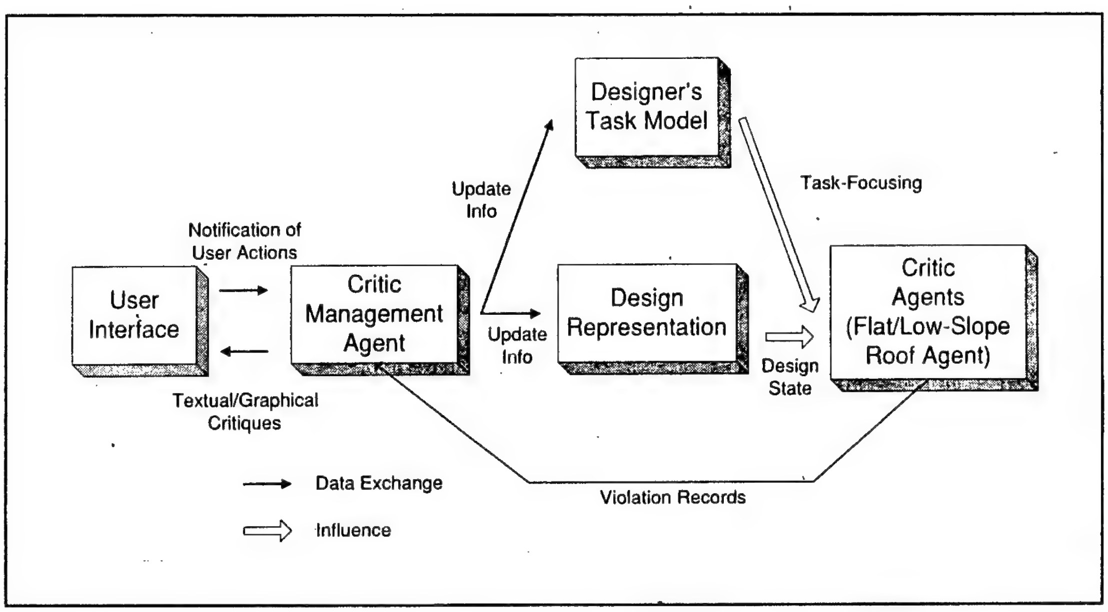


**Figure 1. The SEDAR architecture.**

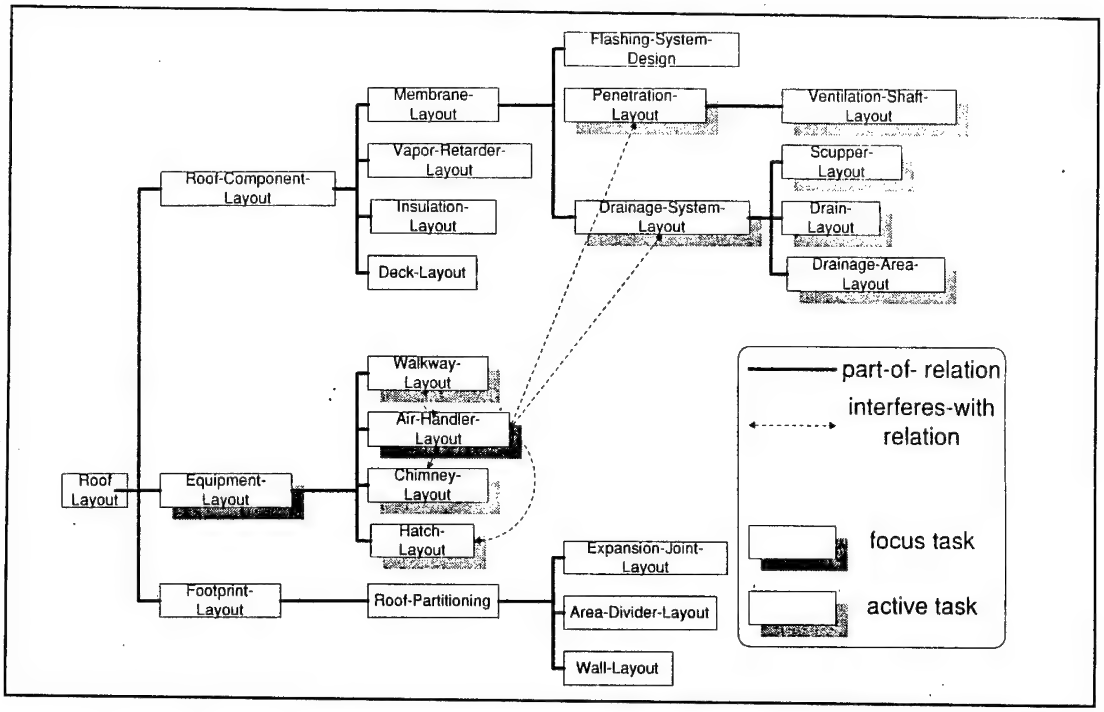


**Figure 2. An activation pattern on the Designer's Task Model.**

Only the interferes-with links related to the Air-Handler-Layout task are shown in Figure 2. For example, the Air-Handler-Layout and Walkway-Layout tasks are related by an interferes-with link because walkways should not overlap air-conditioning units. Each subtask in the DTM is associated with a set of design codes in the Flat/Low-Slope Roof Agent specifying acceptable placement conditions.

As a designer works on the roof design, the DTM is used to track the designer's focus of attention. Each task in the DTM is either an inactive, active, or focus task. The set of all task states in the DTM forms an activation pattern. Focus tasks represent SEDAR's interpretation of the user's current focus. Each task is associated with a set of design objects; when a new object is added to the design, all tasks associated with the object and all of the tasks' ancestors in the part-of hierarchy are focus tasks. In Figure 3, the user's selection of a masonry chimney object causes the Chimney-Layout task and its ancestor, the Equipment-Layout task, to become focus tasks. Active tasks are related to the focus tasks by an interferes-with relation, are subtasks of a task with an interferes-with relation to a focus task, or were focus tasks previously. They represent tasks that have been and should be considered by the user. Finally, inactive tasks are those that have not been addressed yet by the user. During the critiquing episode, SEDAR uses only those design codes that are linked with focus and active tasks so that the resulting critiques and suggestions are relevant to the user's focus of attention. When the user selects the chimney object, SEDAR uses the error prevention strategy to show "off-limits" areas on the design based on the design codes in the Flat/Low-Slope Roof Agent (Figure 3). If the user disregards the advice and places the masonry chimney too close to an existing chimney, SEDAR generates a critique of the chimney placement (Figure 4). Thus the DTM is used

in a flexible manner to track instead of to constrain the user's behavior, and results in relevant critiques and design suggestions.

A design reviewer may use the design review strategy to consistently and comprehensively check subsystems of a roof design according to the design codes in the Flat/Low-Slope Roof Agent. The reviewer selects a roof subsystem from a textual representation of the DTM, and the design review strategy checks the corresponding subsystem in the roof design.

### *Prototype Evaluation*

A prototype of SEDAR was evaluated in two experiments. The first experiment was a system usability evaluation, which rated the performance of SEDAR along various usability issues. While the full results of this experiment are reported elsewhere (Fu 1995), one outcome of this experiment was an informal validation of the functional decomposition of roof subsystems of the DTM. The second experiment measured the prototype system's error reduction effectiveness, and showed that SEDAR is able to reduce both the total number of errors and the classes of error made by roof designers.

The two classes of errors that the system was not able to prevent were optimality issues regarding object placement; although the placement of the design object satisfied the design codes, the object was placed in a "suboptimal" location. Although the SEDAR prototype does not deal with the optimality of subsystem design, recognizing and advising in these situations was expressed as a need by the system evaluators for future development. Additionally, we are

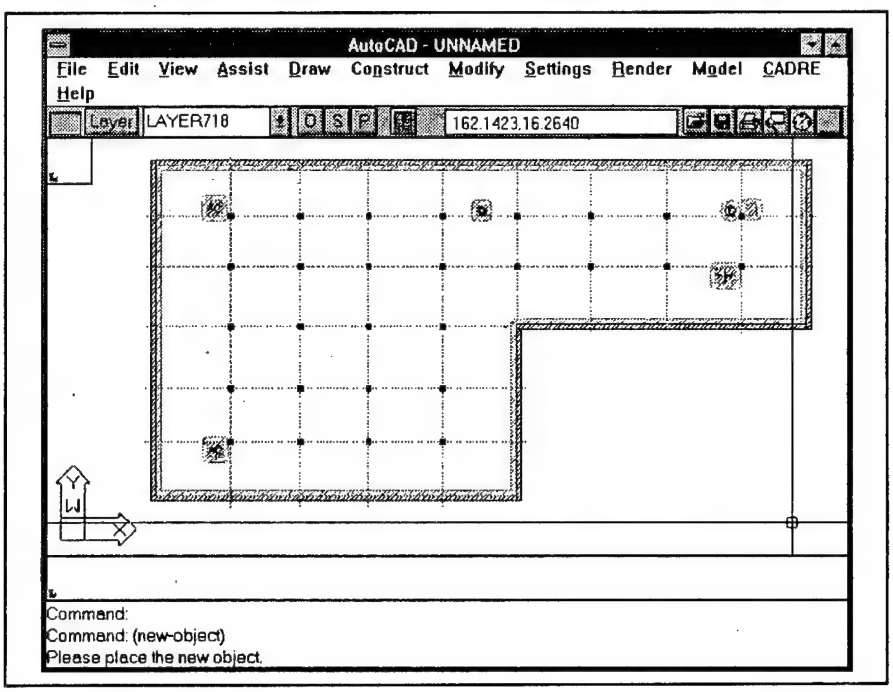


**Figure 3. Results of the Error Prevention Critiquing Strategy.**

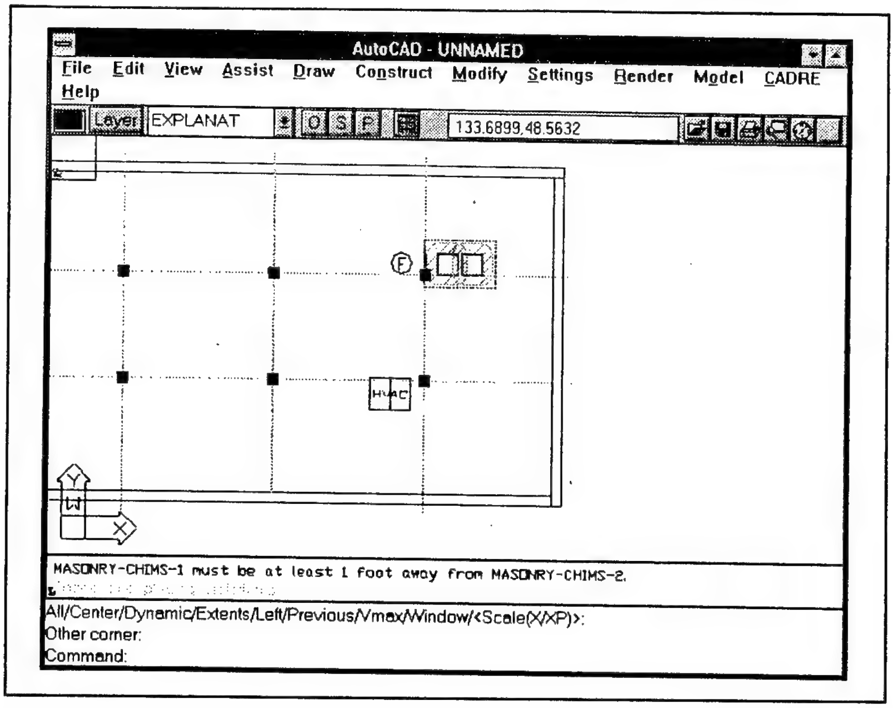


**Figure 4. Enlarged view of a Graphical/Textual Critique.**

looking at ways of critiquing and supporting designers throughout the design process, from early conceptual design to later detailed design (e.g., Brown and Chandrasekaran 1986).

## *Conclusions*

Functional information is needed for a variety of tasks in the design process. This paper describes the use of a functional task decomposition, the Designer's Task Model, to provide both flexibility and relevance to an automated design critiquing system called SEDAR. The goal of SEDAR is to provide automated support for designers and reviewers which can effectively and efficiently reduce the number of errors made in the design process. A prototype implementation of SEDAR has been evaluated, and showed that SEDAR's critiquing strategies successfully reduced the number of errors made by designers.

## *References*

Brown, D., and B. Chandrasekaren, (1986). "Knowledge and control for a mechanical design expert system." *IEEE Computer*, 19(7), 92-100.

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Fu, M., (1995). Using A Task-Based Model of Design for Flexible Control in an Expert Critiquing System, Masters thesis, University of Illinois at Urbana - Champaign.

Griffin, C., (1982). *Manual of Built-Up Roof Systems*. 2nd Ed., McGraw-Hill Book Company, New York, NY.

## Tri-Service CADD Center's Electronic Bid Document Efforts

by Ronson C. Kung[14]

### *Description*

The Tri-Service Center has developed a prototype showing how contract bids could be delivered to contractors electronically on CD-ROM. This prototype is the culmination of effort by Air Force, Army, and Navy personnel dedicated to the pursuit of electronic distribution.

### *Objective*

The intent of this project is to replace existing paper reproductions of contract bid sets in favor of electronic bid sets.

### *Discussion*

Based on a survey taken from NCCOSC RDTE DIV San Diego's contractor bidders list, the following assumptions can be made: contractors are novice users of personal computers; contractors require applications that are simple to operate and easy to use; a majority of contractors already own and use personal computers; the predominate operating system is Microsoft® Windows; a majority of contractors own laser printers; few contractors own plotters; a majority of contractors would be interested in electronic contract bids if offered through CD-ROM or modem technology.

In evaluating how the Department of Defense can distribute contract bid sets electronically, the following statements were made:

Transition to electronic contract bid sets needs to be gradual. It is the intention of this project to provide contractors with an option of receiving bid sets by CD-ROM or through the Internet. As contractors become more efficient with the use of computers and modem technology, the distribution of CD-ROM may be phased out. Contractors would be more inclined to use electronic contract bid sets if software were made available to view and print the document royalty-free. Engineering drawings will be distributed in CALS format, which is consistent with DOD raster drawing standards and may also include CADD drawings in their native file formats (DGN, DWG).

Due to the complexity and detail of CADD drawings, native CADD file drawings tend to require high-end computers for displaying images. In general, contractors are not expected to own high performance computers or costly CADD packages for viewing engineering drawings. However, CADD files may be included as part of the contract bid set.

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Raster drawings in CALS format provide compact files that reduce disk space use and speed transmission through the Internet. Raster drawings also provide contractors with an exact duplicate of paper drawings in electronic format.

Reproduction of engineering drawings by contractors should require little technical knowledge when printing or plotting. Printing or plotting raster drawings will eliminate the need to provide specialized font styles, level/layer settings, scaling, and printer settings.

Reproduction services can be provided by commercial printing services.

Amendments will be initially sent by paper or floppy diskette. Amendments will also be available over the Internet.

Use of commercial software applications is highly desirable since technology tends to outpace development.

Contract specifications and clauses should be capable of being viewed, searched, and reproduced without requiring contractors to purchase a viewing program. Specifications and contract clauses will be provided in PDF file format to alleviate nonstandardization of contract bid documents. Currently DOD uses a variety of software applications. Translation problems and version incompatibilities occur if documents are distributed in native file formats. PDF is a neutral file format currently used by many within the computer industry as a standard for distributing electronic documents. Contract bid sets are a hybrid of complex text and graphics. Since standards do not exist within the text and graphics community, the most popular standard file formats were selected—PDF and CALS respectively. Evaluation of royalty-free viewers capable of viewing PDF and CALS file formats resulted in the use of two applications, Adobe's Acrobat Reader and Dataware's SourceView. Acrobat Reader was selected to provide users with capabilities such as zooming, bookmarks, links, and text searches for PDF files; SourceView Reader was selected due to its ability to view CALS images and provide users with zooming, measuring, and linking features.

### *Other Initiatives*

Currently, emphasis of FACNET and EC/EDI has been targeted in the area of small purchase acquisition where the majority of contracting actions reside. Traditionally, small purchase contracts over $25,000 require Commerce Business Daily (CBD) announcements. Use of FACNET will raise the CBD threshold to $100,000.

Implementation of FACNET for many DOD agencies begins with processing contracting actions (request for quotations or RFQ) through the Standard Army Automated Contracting System (SAACONS). The RFQ is sent to gateways where it is translated into the mandated EDI message format (XI2) for the Federal Government. Through these gateways, an RFQ is sent to Network Entry Points (NEP), which are referred to as Value Added Networks (VANs). These VANs are private industry-owned services which compete for vendor/

contractor business. VANs charge vendor/contractors for the distribution of government solicitations and the sending of bids back to government agencies in the appropriate format.

Due to FACNET and EC/EDI's emphasis on small purchase acquisition, the design of FACNET does not lend itself to the electronic distribution of large engineering drawings and specifications. In addition, EDI X12 transaction set number 841 for technical information is a standard that has not been implemented and may not be capable of handling engineering drawings. Additional testing will be required before X12.841 becomes a standard transaction set for engineering drawings.

### *Concept*

This initiative will provide contractors an option of receiving contract bid sets in either a CD-ROM format or by downloading files through the Internet. The CD-ROM version will contain all data related to the project and include royalty-free viewers for quick access and viewing. Although no software installation will be required, contractors may want to install the viewers onto their hard drives to increase access time.

The concept of downloading files through the Internet will require access to the World Wide Web. Using a web browser, contractors will be given the opportunity to query a database of all advertised contracts submitted to a centralized server. Queries to the central server will result in an HTML list of contract advertisements meeting the search criteria. Each advertisement will be linked to the activities web site, where contractors will be allowed to view contract descriptions, specifications, contract clauses and drawings on-line, download all associated files, or order the CD-ROM.

Contractors with e-mail, fax, or plan room access will be allowed to subscribe to an automated mailing list that will send notices of contract advertisements to contractors based on default search criteria. Requests beyond the default criteria will require contractors to search the central server as stated above.

### *Benefits*

The benefits derived through this project include reduction in reproduction costs, mailing costs and storage space used to archive contract bid documents.

### *Vision*

The transition to electronic contract bid requires options which allow contractors to slowly and progressively migrate towards electronic contract bid. The implementation of FACN-ET, EC/EDI, and other electronic contract initiatives such as this project will continue to progress and be refined as changes in technology occur. Eventually, lessons learned through these initiatives will serve as a common thread for development of a comprehensive electronic contract bid process capable of providing contractors with a centralized contract network.

### *Requirements*

The CD-ROM delivery of electronic contract bids will require either Windows 3.1™, Windows NT™, or Windows 95™. The recommended hardware requirements are 486/33Mhz with 16MB RAM or better and a Super VGA monitor (800 x 600 resolution). The absolute minimum hardware requirements are 386 with 8MB RAM and a VGA monitor (640 x 480 resolution). Please note, speed and performance depend on processing power and the amount of RAM available.

Internet access may be required to receive on-line electronic contract bids. File transfer speeds depend on the speed of modems used by the receiver and sender. On-line access may require subscriptions to plan rooms, VANs, or service providers.

### *Test Sites*

Contact one of the persons listed below for the latest information on test sites:

J. Justin Taylor, Corps of Engineers, HQUSACE-MP-ES, 20 Massachusetts Ave. NW, Washington DC 20314-1000. Phone: 601-634-2152, Fax: 601-634-3448, e-mail: taylor@exl.wes.army.mil.

David Skar, Naval Facilities Engineering Command HQ, 200 Stovall Street, Alexandria, VA 22332. Phone: 703-325-7360, Fax: 703-325-2261, e-mail: djskar@ha.navfac.navv.mil.

Captain Mike Stimson, HQ AFMC/CECC, 4225 Logistics Ave., Suite #7, Wright Patterson AFB, OH 45433-5746. Phone: (513) 257-7214, Fax: (513) 257-1830, e-mail: stimson@afrncce.wpafb.mil.

## The Modular Design System (MDS)

by Eric Griffith[15]

### Outline

What is MDS?
Who is using it?
How is it going to be managed?
What are future developments?

### Modular Design System

Developed by Louisville District as the Center of Standardization for Army Reserves. MDS is a component module design approach for defined facility types. Modules are configured within defined grids. It is developed within MicroStation. First Facility Type - Army Reserve/National Guard (AR/NG) Training Centers. System Delivery - 15 January 1996. It has been under development for 3+ years.

### Three Module Types

Fully Designed Modules: The modules are completely and independently designed for a specific programmatic function.

Planning Modules: The modules track programmatic functional criteria, but the modules have not been completely designed.

Structural Modules: Structural modules define structural spacing and control member selection. A limited number of sizes are available—32 x 32 predominately.

### Information Flow

A "Layout" of modules is created on a selected grid. The layout is converted to Architectural Drawings. Doors, windows, and wall finishes are user input.

Now, the other disciplines can proceed. Most of the disciplines do not design systems, but aid in documentation (i.e., duct sizes are not determined, but tools are available to connect diffusers, supplies, and returns). Drawings are completed in native MicroStation.

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### MDS Products

DD 1391 - Documents for Congressional Approval, Construction Documents (Plans and Specifications) 75%, Cost estimates at each stage, Furniture purchasing requirements.

### Who Is Using It Today?

- Louisville District
- Two Indefinite Delivery Contractors
- Various State National Guard Agencies
- MDS Supports 75% of the Design Production activities for AR/NG

### MDS Future Vision

- The facility delivery system for standard facilities within the Army
- The facility delivery system for standard facilities within the DoD
- The facility delivery system for "recurring buildings" within the Federal Government
- Re-engineer the federal facility delivery process

### MDS Defined as APIs

MDS-API Core: The core program functionality including data representations, system software, and CAD program interfaces.

Engineering Discipline-API (ED-API): Builds from the MDS-API to meet the functional requirements of each technical discipline as needed by FT-APS. This includes data definition and routines specific to the ED-API.

Facility Type-Application Program (FT-AP): Utilizing the ED-APIs, an FT-AP is developed to meet the needs of specific facilities. This includes data definition and FT-AP specific routines.

### Organizational Roles for MDS Activities

- MDS Proponent - HQUSACE - CEMP-EA
- Program Agent - Tri-Services CADD Center
- Technical Agent - USACERL
- Engineering Discipline Committees
- Facility Type Application Committees

### MDS Within the Corps

- Module Creation Program
- New Facility Types: Vehicle Maintenance Shops, Barracks
- Build support outside the Army: Bureau of Indian Affairs
- Contractor has asked to utilize MDS on an unrelated government project

### *MDS Cooperative Research and Development Agreement*

- Partners: IdeaGraphix/Softdesk, Bentley Systems, JMGR, and Building Systems Design
- Open Collaborative Engineering Framework: Semantic Object Representations, Plug and Play Architecture, Conflict Processes, Repositories
- Design Review an important issue for future work

# 7 Summary

## Toward a Design Review Lessons-Learned System

by Donald K. Hicks, Jeffrey G. Kirby, and E. William East[16]

In their role as Construction Manager for the U.S. Army, U.S. Air Force, and other Federal Agencies, the U.S. Army Corps of Engineers is constantly striving to improve the quality of the Facility Delivery Process and the product—the facility that is delivered to their customers. Essential to this effort is the design review process and the effective capture and use of the lessons learned. On 23-25 January 1996, the U.S. Army Construction Engineering Research Laboratories (USACERL) hosted the "Design Reviewer's Support Environment Project Steering Committee Meeting" in Champaign, IL.

The purposes for this meeting were: (1) to determine the current state of the practice of design review tools, primarily but not exclusively within the Corps of Engineers, (2) to identify promising directions for future research efforts into design products and systems, and (3) to identify members of the steering committee who would be willing to evaluate and jointly develop future design review tools. This paper summarizes the events of this meeting.

Attending the meeting were Corps of Engineers personnel from all organizational levels who were responsible for ensuring that the facility delivery process and, specifically, the construction plans and specifications are of the highest possible quality. Private sector construction document code review professionals and graduate student research assistants also attended. A list of persons attending this meeting is provided on p 68.

The meeting was organized in three distinct segments. First, attendees spoke describing design-review and design-review-oriented lessons-learned systems and processes currently used across the Corps of Engineers. Prototype systems to support the design review and lessons-learned systems were presented. Innovative systems developed outside of the Corps of Engineers were also presented to illustrate specific capabilities and interests. Then the group developed a listing of prioritized major issues, believed to be the most significant, facing the design profession and, more specifically, the Corps of Engineers' interest in design review. And finally, the group identified what actions were required to facilitate the implementation of solutions and who would be the most appropriate initiator and proponent of each action item.

[16] All from: Commander, U.S. Army Construction Engineering Research Laboratories, P.O. Box 9005, ATTN: CECER-PL-E, Champaign, IL 61826-9005.

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|---|---|---|---|
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| Johnny Baggette | South Atlantic Division | | |
| Margie Crumley | Omaha District | | 402-221-3979 |
| Bill East | CERL | b-east@cecer.army.mil | 217-373-6710 |
| John Hart | Ohio River Division | john_hart@smtp.ord.usace .army.mil | 513-684-3803 |
| Terry Houghton | HQ | Terence.Houghton@inet. HQ.usace.army.mil | 202-761-0427 |
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| Ronson Kung | WES | kungr@ex1.wes.army.mil | 601-634-3181 |
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| Norman Sams | Alaska District | Norman.D.Sams@NAP01. usace.army.mil | 907-353-7556 |
| Stephen Stoner | ARMS | Stoner@usace.army.mil | 916-557-7676 |
| Justin Taylor | HQ | jtaylorj@ex1.wes.army.mil | 202-761-1246 |

By way of an introduction to the meeting, six possible domains of interest were presented as a context into which the meeting outcomes could be framed. They were: (1) Operating Systems for work groups, graphical users interface (GUI), and multimedia, (2) Electronic Bid Documents to mark-up reviews and for printing cost avoidance, (3) Lessons-Learned for daily uses and after action documentation, (4) Automated Review Management System (ARMS), which provides work group support, suspense tracking, and routing, (5) Internet (WWW) for information access, work group support, and data depository, and (6) Computer-Aided Design and Drafting (CADD) systems for collaborative environment and lines of communication. The challenge to the meeting participants was to integrate any of the possible solutions with the above cited resources while realistically measuring the solutions against the resource limitations, changing workloads, and the requirement for faster design review cycle time.

### *Summary of Presentations*

The following topic sessions were conducted during the meeting. In general, all of the attendees presented the results of their efforts or the results of their organization at one or more of the sessions. The session topics were developed with the intent to further define the purposes of the meeting.

*Automated Review Management System (ARMS)*: ARMS is a Corps of Engineers system developed to support the management of the design review process as practiced by the Corps of Engineers. The Sacramento District office is the center for technical expertise for ARMS. ARMS users discussed current use of the system. Several District offices and USACERL have developed programs to enable the generation of "off-line" review comments that then can be forwarded to the ARMS central computer. There were presentations of the systems by their

users/developers. These programs were discussed by the committee. ARMS implementation barriers were discussed.

*Reviewer's Assistant and the Lessons-Learned Generator*: The Corps of Engineers recognizes the need for design review support and directed USACERL to execute Research and Development to meet this need. The results of USACERL's effort has been the development of a design review support system, the Reviewer's Assistant, and a lessons-learned system, the Lessons-Learned Generator. Together they collect, abstract, and compile commonly referenced review comments. The two systems have been developed to support the design review process commonly used by Architect/Engineer (A/E) offices. The Reviewer's Assistant is an integrated text editor, database, and communication software package in which reviewers create, store, and query for applicable review comments. The Lessons-Learned Generator performs a statistical analysis of the usage patterns of review knowledge stored in the Reviewer's Assistant databases, performs an abstraction process on commonly referenced review comments, and compiles them into a lessons-learned database. Together the two systems form a powerful and flexible tool for design reviewers.

*Lessons-Learned Initiatives*: The Corps of Engineers recognizes that there must be a continuing evaluation of the functional responsiveness and technical performance of the Corps' practices of design, construction, and post-construction for constructibility, engineering and technical sufficiency, life-cycle cost performance, lessons-learned technical feedback, and compliance with current design and construction criteria. The Corps has established various requirements and methods to obtain, evaluate, and incorporate recommended changes in design and construction policy, guidance, and criteria. In addition to the policy established by the Corps, several District offices have initiated local level programs to capture and use lessons learned. The question of whether the lessons-learned system should be a separate system or integrated with other systems, such as the Reviewer's Assistant, was discussed. All of the participants strongly believed that capture and use of lessons learned was a key component of the Corps' ability to deliver quality facilities that meet the user's needs.

*Other Corps of Engineers Review Process Reports*: Several participants reported on how their organization conducts and manages design reviews. Since each Corps District and Division office operates autonomously, this was of particular interest to the group. Some offices have not as yet opted to implement any of the available automation support, and this discussion was of value to their decision-making process.

*Electronic Bid Documents*: With the advent of electronic bidding documents and the fact that several district offices are testing them on specific projects, the group discussed the potential of using this media to its maximum in the design review process. The process of issuing electronic bid documents, controlling the versions, security issues, and document management were discussed. All recognized that the new media posed new challenges that needed to be addressed in order to successfully manage the task and comply with Federal

Acquisition Regulations. It was also concluded by the group that the benefits of the electronic document media outweighed the negative aspects.

*Design Review Related Prototype Systems*: Several new commercial and Corps developed systems were discussed by the group with the specific interest issue of how they could support the design review process as well as customer satisfaction. "Lotus Notes" was demonstrated to the group and discussions followed as to the practical application of the system to the design review process. The Corps of Engineers developed "Modular Design System" (MDS) was demonstrated and discussed also. The feasibility and functional ability of computer-assisted design reviews were discussed. How they might support the process, their functionality, and the current state of development were discussed. The group concluded that the future holds much promise in this area.

*Design Review Systems, "The Next Generation"*: Given that the group recognized the need to further enhance the design review process, thoughts were directed to the possibility of capitalizing on recent advances in technology as well as the Corps' emphasis on improving the Facility Delivery Process from the customers unique point of view. Specific next generation tools identified for discussion included: new hardware/software platforms, groupware/routing systems, screen layout and configuration with graphical user interfaces, electronic document mark-up capabilities, design data as well as graphical (drawings) data, the most effective and efficient means of transferring to the next generation, adaptable commercial systems in use, regulatory requirements, the World Wide Web Internet systems as a supporting capability of design review, and efficient and effective technology transfer through adaptive and intuitive systems.

### *Summary of the Breakout Groups*

As a group of the whole, the committee discussed what were the major issues that needed to be addressed for the "Next Generation System" for design review support. An extensive list of topics was developed and discussed in an unrestricted free flow environment. The committee then divided into two smaller subgroups (Group A and Group B) and selected topics of interest from the full list of issues. The two groups were then tasked to prioritize their topics in terms of importance and to develop potential solutions, recommendations, and suggestions for the resolution of their highest ranking topics as time permitted.

Each group then further defined and refined their topics to the point of consensus, consolidated where possible, and prioritized the topics, most important to least. The groups then discussed and analyzed the topics, developed solutions and recommendations, and made preparations for presentations to the committee as a whole.

Group A reported their top five issues as: (1) a shared lessons-learned system with user friendly interface, (2) improve the design review process, (3) provide leading edge solutions, not bleeding edge, (4) provide within the design review process a mechanism for Architect/Engineer evaluations based on the quality of

the documents, and (5) provide a feedback system that addresses the change order process.

Group B's top four issues were: (1) user friendliness (software ergonomics), (2) lesson-learned feedback mechanism, (3) simplification of the design review process, and (4) interface with industry. Group B reported on their top issues in terms of (a) technical issues, (b) adoption by the user community, (c) approval, (d) process issues, and (e) industry partnership issues.

### *Action Items*

As a result of the committee's review of the existing design review process condition and the brainstorming session on what the next generation of design review systems could be, the following is a list of the actions needed in order to advance the effective design review process and product.

1. Recommend that ARMS is actively used by all elements of the Corps of Engineers, including the Civil Works Directorate. The tools are there, use them—ARMS+, Reviewer's Assistant, and PC ARMS.

2. Create a prototype "Lessons-Learned" World Wide Web (WWW) site with e-mail to promote the exchange of information among all design reviewers. Private sector use of this data may also be explored.

3. Create a WWW site for the Steering Committee for the exchange of information among committee members.

4. Develop system design guidance that would ensure that future review systems would be modular and therefore compatible with each other and with future systems.

5. Proceed with the cooperative research and development agreement to develop a plan checking system.

6. Develop a system or mechanism to provide design references and criteria electronically to the design reviewers.

7. Proceed with the development of the capability to electronically "mark-up" design drawings.

8. Improve connectivity of the remote offices by design review community to the WWW.

### *Conclusions*

The consensus of opinions of the conference attendees was: (1) that the need for efficient and effective design reviews of construction documents are more important now than ever, and they are essential for customer satisfaction, (2) the Internet offers opportunities in which all of the facility acquisition process

participants can become connected, and with this connectivity the communication process will be greatly facilitated, and (3) to remain a viable participant in the process there must be a strong commitment to using advanced technologies to improve the way in which we provide our services to our customers.

The group recognizes that there are at least two remaining issues to be resolved: (1) whether the design review process will remain as individual reviewers generating their comments without collaboration or interaction or will it become a "virtual design conference" and (2) will the ultimate tool become embedded in the design review process or will it be a reference material that is used at the discretion of the reviewer?

## Distribution

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